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An Annotated Checklist of the Terrestrial Mammals of Los Angeles County Part II: Eulipotyphla, Carnivora, Artiodactyla, and Chiroptera

Brad R. Blood

Psomas, 5 Hutton Centre Drive, Santa Ana, CA 92707, bblood@psomas.com

Abstract.—An annotated checklist of the terrestrial mammals of Los Angeles County was compiled, based on over 10,000 museum records spanning over 100 years of scientific research. Part 1 covered 42 species in the orders Didelphimorphia, Lagomorpha, and Rodentia. Part II provides an annotated list and abbreviated synonymies for 46 species of terrestrial mammals in the orders Eulipotyphla, Carnivora, Artiodactyla, and Chiroptera.

Part I of this checklist reported on 42 species of terrestrial mammals in the Orders Didelphimorphia, Lagomorpha, and Rodentia (Blood 2021). Part II reports on 46 species of terrestrial mammals in the Orders Eulipotyphla (3), Carnivora (15), Artiodactyla (4), and Chiroptera (24). The purpose of this checklist is to update the Mammals of Los Angeles County, first published by the Natural History Museum of Los Angeles County in 1944 (Willett 1944) and updated in 1959 (McLaughlin 1959). Willett (1944) reported 65 species of terrestrial mammals in Los Angeles County, and McLaughlin (1959) reported 69 species of terrestrial mammals. Currently, Los Angeles County has documented records for 88 species of terrestrial mammal species in seven Orders.

Part II of this checklist includes nine species that were not reported previously in McLaughlin (1959): *Vulpes vulpes*, *Sus domesticus*, *Choeronycteris mexicana*, *Nyctinomops femorosaccus*, *N. macrotis*. *Lasionycteris noctivagans, Dasypterus xanthinus, Myotis lucifugus*, and *M. velifer*. This checklist also includes four species that were reported in McLaughlin (1959), but at the time were listed under different species, which have subsequently been changed due to taxonomic revisions. These species are *Notiosorex tataticuli*, *Aeorestes cinereus*, *Lasiurus frantzii*, and *Myotis ciliolabrum*. *Notiosorex tataticuli* was split from western populations formerly considered *N. crawfordi* (Camargo and Álvarez-Castañeda, 2020). *Aeorestes cinereus* was formerly considered *Lasiurus cinereus* and *Lasiurus frantzii* was split from *L. blossevillii* (Baird et al. 2015). McLaughlin (1959) listed *L. blossevillii* as *L. borealis*. In 1959 *Myotis ciliolabrum* was considered a subspecies of *Myotis subulatus* (*M. subulatus* is now considered a synonym of *M. ciliolabrum*). The pronghorn (*Antilocapra americana*), reported herein, was listed by Willet (1944), but not by McLaughlin (1959). Willet (1944) reported that at the time pronghorn may be extinct in Los Angeles County, but that pronghorn were known to have been present in the county within the previous 10 years. McLaughlin (1959) listed the spotted bat, *Euderma maculatum* in Los Angeles County. I found no museum records for Los Angeles County; however, the California Natural Diversity Data Base (CDFW 2021a) has two reported locations of the spotted bat in Los Angeles County, and so this species is included on this checklist; however, one of those two localities is in question.

This checklist is the result of research for a larger project documenting the presence, distribution, and natural history of terrestrial mammals throughout southern California and the southern and eastern Sierra Nevada (Blood 2018).

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Materials and Methods

The taxonomy and nomenclature used in this checklist generally follows Bradley et al. (2014) and Burgin et al. (2020a, b) and reflects the most recently accepted nomenclature at the order, family, genus, species, and subspecies level based on a review of recent scientific literature. Common names generally follow those used in Bradley et al. (2014). Taxonomy above the genus level follows Burgin et al. (2018). Species and subspecies distributions are based on Hall (1981) modified with more recent literature. Museum records for mammals in California were downloaded from the IDigBio database in 2017 and again in 2020 (IDigBio 2020). Records originated from multiple museums (Appendix I) and the variation in identifications of those records reflect differences in curation, including unknown delays between specimen collection, curation, and installation into the collection, resulting in species identifications based on the nomenclature available at the time of curation. All records were reviewed for consistency in species nomenclature and edited into a consistent format, i.e., genus, species, and subspecies, or genus and species. Records identified to genus only and family only or as fossils were not used.

The edited records were imported into Psomas's Geographic Information System (GIS). Records were mapped as point localities using latitude and longitude (decimal degrees) present in the raw data. Point localities with more than one record were mapped as a single point. Distribution maps for each species and its subspecies were reviewed and updated by matching the distribution against available maps and literature. Erroneous records were corrected, such as species and subspecies records located well outside the accepted distribution of that taxon. Records with text only localities were not used. Elevation ranges were obtained from the resulting point locality records using GIS analysis and are reported for Los Angeles County only. The range of each species and its subspecies in Los Angeles County were determined by plotting the point localities onto a map of Los Angeles County (Fig. 1) and then analyzed using a web viewer developed by Psomas for this project. The distributions and elevations reported herein should therefore be considered a conservative estimate. This checklist has relied generally on museum records because observational records of species identifications cannot be verified. Museums represented in the database for which specimen records from Los Angeles County were used in this checklist are listed in Appendix 1.

However, because the species covered in Part II of this check list are not as well represented in museum collections as those presented in Part I, I have supplemented the museum data with observation data and location records from the California Natural Diversity Database (CNDDB) (CDFW 2021a). I have also queried the iNaturalist web site (https://www.inaturalist.org/observations) for species not well represented in the data set. Before I included an iNaturalist observation, I viewed the photograph to determine it was the taxon indicated. These alternate records for locality are reported if they provided significant additional information.

Annotated Checklist of the Terrestrial Mammals of Los Angeles County: Part II

Order Eulipotyphla

Family Soricidae: Shrews

Notiosorex tataticuli: Ticul's Desert shrew

Notiosorex tataticuli Camargo and Álvarez-Castañeda, 2020:878. Type locality is "Mexico: Baja California Sur; 4 km N, 6.6 km W El Sargento, 24.1189°N, 110.0670°W, 675 m a.s.l."

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Fig. 1. Los Angeles County.

N. t. ocanai Camargo and Álvarez-Castañeda, 2020:880. Type locality is "Mexico, Baja California; 22.5 km S San Quentin (30°22'17" N, 115°51'52" W)."

Based on genetic and morphometric analysis, Camargo and Álvarez-Castañeda (2020) split *N. tataticuli* from the more widespread *N. crawfordi,* which is now restricted east of

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the Colorado River in the United States. *N. taticuli* ranges from west of the Colorado River into the Mojave Desert to the Transverse Ranges of California and Nevada in the United States and throughout all the Baja California Peninsula in Mexico (Camargo and Álvarez-Castañeda 2020). Populations in California west of the Colorado River are *N. t. ocanai*.

Of three recognized subspecies, one occurs in Los Angeles County: *Notiosorex tataticuli ocanai* (Camargo and Álvarez-Castañeda, 2020). In Los Angeles County, Ticul's desert shrew has been recorded from only a few localities, including the San Gabriel Mountains and the hills and canyons north of Canyon Country. There is one record from the Santa Monica Mountains and two records from the Los Angeles Basin in areas that are now fully developed and no longer support suitable habitat. There are also records from the Ballona Creek upstream of the Ballona Wetlands Ecological Reserve. But it has not been recorded as occurring at the Ballona Wetlands Ecological Reserve (Friesen et al. 1981; Johnson 2012). Vaughan (1954) reported a record from 2 miles northeast of Claremont on the Pacific slope of the San Gabriel Mountains. Ticul's desert shrew occupies drier sage scrub and chaparral habitats than does *Sorex* (Cunningham 1956; Armstrong and Knox-Jones, Jr. 1972; Laakkonen et al. 2001; Tremor et al. 2017). This species appears to be most abundant in areas near bodies of water or with vegetative cover (Camargo and Álvarez-Castañeda 2020). Elevation records from Los Angeles County range from 11 to 722 m.

Sorex ornatus: Ornate shrew

Sorex ornatus Merriam, 1895:79. Type locality is "from head of San Emigdio Canyon, [at about 5500 feet altitude, in dense grass in boggy place, on north side of] Mount Pinos, [Kern County] California." Text in brackets added by Grinnell (1933).

Sorex willetti von Bloeker, 1941:163. Type locality is "Avalon Canyon, Santa Catalina Island, Los Angeles County, California."

Sorex obscurus parvidens Jackson, 1921:161. Type locality is "Spring known as Thurman's Camp, Bluff Lake, altitude 7,500 feet, western side of San Bernardino Peak, San Bernardino Mountains, California"; corrected by Jackson (1928:124) to "Spring known as Thurmans Camp, Bluff Lake, altitude about 7,500 feet, San Bernardino Mountains, Calif."

Sorex vagrans parvidens Findley, 1955:58. See above.

S. o. ornatus Jackson, 1928:166. First use of current name combination. See above.

S. o. parvidens Woodman, 2012:837. First use of current name combination. See above.

S. o. salicornicus von Bloeker, 1932a:131. Type locality is "Playa del Rey, Los Angeles County, California."

S. o. willetti von Bloeker, 1967:247. First use of name combination. See above.

Of nine recognized subspecies, four occur in Los Angeles County: *Sorex ornatus ornatus*, *parvidens*, *salicornicus*, and *willetti* (Hall 1981; Owen and Hoffmann 1983; Woodman 2018). In Los Angeles County the ornate shrew has been recorded from Santa Catalina Island (*S. o. willetti*), along the coast including the Palos Verdes Hills, Marina del Rey; and the Santa Monica Mountains (*S. o. salicornicus*); and inland including the Los Angeles Basin; Sycamore Canyon near Rose Hill Memorial Park; scattered locations north of State Route 14 including near Lake Hughes; Cruzan Mesa; and the San Gabriel Mountains in San Antonio Canyon (*S. o. ornatus*). There are three records of *S. o. parvidens* from

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Los Angeles County in San Antonio Canyon near Mt. Baldy (reported as Camp Baldy by Vaughan 1954) close to the border with San Bernardino County. Friesen et al. (1981) and Johnson (2012) reported the ornate shrew as known to occur at the Ballona Wetland Ecological Reserve, but neither study captured any individuals. The ornate shrew occupies a wide variety of habitats including valley foothill and montane riparian; woodlands; chaparral; sage scrub; grassland; brackish saline marshes; and emergent wetland habitats (Owen and Hoffmann 1983; Laakkonen et al. 2001; Tremor et al. 2017). It prefers moist habitats with dense understory vegetation. *S. o. salicornicus* is also known as the southern California salt marsh shrew and is a California Species of Special Concern (CDFW 2021b). Elevation records for Los Angeles County range from 2 to 1,496 m.

Family Talpidae

Scapanus latimanus: Broad-footed mole

S[*calops*]. *latimanus* (Bachman, 1841:41). Type locality is Santa Clara, Santa Clara Co., California (Peters 1863; Osgood 1907).

Scapanus latimanus: Osgood, 1907:52. First use of current name combination.

S. l. occultus Grinnell and Swarth, 1912:131. Type locality is "Santa Ana Cañon at 400 feet altitude, Orange County, California."

Of the five recognized subspecies of the broad-footed mole, one occurs in Los Angeles County: *Scapanus latimanus occultus* (Hall 1981; Verts and Carraway 2001; Woodman 2018). The broad-footed mole is found throughout the Los Angeles Basin. Records are more numerous east of downtown Los Angeles in areas close to the foothills of the San Gabriel Mountains. It is also found in the Santa Monica Mountains; Verdugo Mountains; San Rafael Hills; western foothills of the San Gabriel Mountains; one record from Lake Hughes along the desert facing foothills of the San Gabriel Mountains; and a few scattered localities in the interior of the San Gabriel Mountains (Mt. Gleason, head waters of the Arroyo Seco where it crosses Hwy 2). Vaughan (1954) found moles more common on the Pacific slope of the San Gabriel Mountains and less common on the desert slopes. The broad-footed mole occupies a variety of habitats including grasslands; riparian woodlands; wet meadows; urban parks; and residential areas. It prefers moist, friable soils that are well drained and do not flood (Verts and Carraway 2001). In the San Gabriel Mountains, Vaughan (1954) found moles most commonly in sandy soils in riparian and chaparral habitats. Elevation records for Los Angeles County range from 7 to 1,964 m.

Álvarez-Castañeda and Cortes-Calva (2021) have suggested that *Scapanus latimanus* may consist of three species, of which *occultus* is one. Further analysis is needed that includes samples of all subspecies of *S. latimanus* and also better sampling of moles from the eastern Sierra Nevada.

Order Carnivora

Family Felidae

Felis catus: Domestic cat

Felis catus Linnaeus, 1758:42. Type locality is Europe.

The domestic cat is monotypic. The use of *F. catus* for the domestic cat follows Burgin et al. (2020b) and Gentry et al. (2004). The issue of using Latin binomials for

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domestic forms of animals is partly reviewed in Gentry et al. (2004). I have included this species in this checklist because populations of free-roaming domestic cats have become established in Los Angeles County and have become common-place as demonstrated by citizen observations (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 118552). These observations show that domestic cats are most commonly encountered in the urban and developed areas of the county and are not commonly found in the wild open spaces. Monitoring and tracking of feral cat populations is important because of their effect on birds and other wildlife annually (Winter 2006; Loss et al. 2013) and also because they present public health concerns (Gerhold and Jessup 2012; de Wit et al. 2019).

Lynx rufus: Bobcat

Lynx Kerr, 1792:155. Type species *Lynx vulgaris* Kerr [= *Felis lynx* Linnaeus].
Felis rufa (Schreber, 1777:412). Type locality is "Provinz New York in Amerika."
Lynx rufus: Rafinesque 1817a:46. First use of current name combination.
Lynx baileyi Merriam, 1890a:79. Type locality is "Moccasin Spring, Arizona." Name combination.
L. r. baileyi Bailey, 1932:291. First use of current name combination. See above.
L. r. californicus Mearns, 1897:2. Type locality is "San Diego, California."

Of 12 recognized subspecies, two occur in Los Angeles County: *Lynx rufus baileyi* and *californicus* (Hall 1981; Lariviere and Walton 1997). The records for *L. r. californicus* in Los Angeles County are from the areas of large open space including the Santa Monica Mountains; San Gabriel Mountains; San Gabriel Valley foothill communities; Griffith Park; Verdugo Mountains; San Rafael Hills; and the vicinity of Palmdale. Mathewson et al. (2008) document its continued use of Griffith Park. *Lynx r. baileyi* is recorded from the vicinity of Lake Los Angeles and north of Wrightwood in the Mojave Desert area of northern and eastern Los Angeles County. Vaughan (1954) reports that bobcats occur throughout the San Gabriel Mountains up to 2,590 m. The bobcat has become adapted to living in the urban/suburban environment and can be found in the suburbs surrounding the Los Angeles Basin (Koler 1995; Riley et al. 2003; Larson et al. 2020). Mapped observations on iNaturalist (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 41976) show bobcat use of the open space areas listed above and of those suburban areas adjacent to large open spaces in the county. The bobcat occupies coniferous forests; oak woodlands; riparian woodlands; sage scrub, chaparral habitats and suburban/wildland habitats (Lariviere and Walton 1997; Riley et al. 2003; Larson et al. 2020). Elevation records for Los Angeles County range from 61 to 2,590 m.

Taxonomic Note: Kitchener et al. (2017) recognized four subspecies based on the works of Reding (2011), Croteau (2009), and Loveless et al. (2016). Reding (2011), Croteau (2009), and Loveless et al. (2016) did not make formal taxonomic changes; however, the evidence they present argues for fewer subspecies than the 12 recognized by Hall (1981) and Lariviere and Walton (1997). Based on the data presented in the above cited papers Kitchener et al. (2017) define the presence of two subspecies in North America. A west coast subspecies (*L. r. fasciatus*) and an east coast subspecies (*L. r. rufus*). The transition zone between the two is the Great Plains of North America. They also provisionally name two subspecies in Mexico. Burgin et al. (2020b) follows the conclusions of Kitchener et al.

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(2017). This checklist follows Hall (1981) and Lariviere and Walton (1997) until further research is performed, especially in areas of possible intergradation between their proposed western and eastern subspecies. Additionally, a review of the authorities cited above points to the potential of more than two subspecies in North America.

Puma concolor: Mountain lion

Felis concolor (Linnaeus, 1771:522). Type locality restricted to Cayenne, French Guiana, by Goldman (Young and Goldman 1946).
Felis couguar Kerr 1792:151. Type locality is "Pennsylvania." Name combination.
Puma Jardine, 1834:266
Felis californica May, 1896:22. Type locality "Kern County." Name combination.
Puma concolor: Pocock, 1917:336. Name combination.
F. c. californica Nelson and Goldman, 1929:347. See above.
P. c. couguar Culver et al., 2000:196. First use of current name combination. See above.

Of six recognized subspecies (Culver et al. 2000), one occurs in Los Angeles County: *Puma concolor couguar*. There are only a few museum records of mountain lions in Los Angeles County, which does not provide for an analysis of its distribution in the county. There are two interesting records from downtown Los Angeles from 1907. However, Riley et al. (2014) and Benson et al. (2016) report mountain lions from the Santa Monica Mountains, Simi Hills, and the Santa Susana Mountains. Torres et al. (1996) report mountain lions from the Angeles National Forest. The Santa Monica Mountains National Recreation Area reports that 75 mountain lions have been collared and tracked in the Santa Monica Mountains (https://www.nps.gov/samo/learn/nature/pumapage.htm, accessed 31 January 2020). iNaturalist reports mountain lion sightings from the Santa Monica Mountains; San Gabriel Mountains; Verdugo Mountains; vicinity of Griffith Park; and the Santa Susana Mountains (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 42007). The mountain lion occupies a wide variety of woodland and scrub-chaparral habitats including suburban/wildland habitats (Currier 1983; Culver et al. 2000; Benson et al. 2016; Torres et al. 1996). The mountain lion is also known as puma, panther, catamount, deer tiger, Mexican lion, painter (a corruption of panther), and cougar (Young and Goldman 1946). The mountain lion is also known by a number of other names in Latin America and by indigenous peoples throughout the Western Hemisphere (Young and Goldman 1946), which is indicative of its vast range in the Western Hemisphere from northern British Columbia to Patagonia in Argentina (Young and Goldman 1946; Sunquist and Sunquist 2009).

Taxonomic note: Hall (1981) recognized 15 subspecies of mountain lion in North America. Culver et al. (2000) reduced that number to six using mitochondrial DNA (mtDNA) and composite microsatellite genotypes from 315 mountain lions (wild and captive) representing 32 of 35 subspecies from both North and South America. Culver et al. (2000) recognize *P. c. couguar* in North America and Central America, plus *P. c. costaricensis* in Central America (Costa Rica southward) and four additional subspecies in South America.

Kitchener et al. (2017) recognize two subspecies based on a mtDNA study by Caragiulo et al. (2014). According to Caragiulo et al. (2014) the two subspecies are *P. c. couguar* in North America and Central America and possibly northern South America and *P. c. concolor* in South America. Caragiulo et al. (2014) based their conclusions using a more

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limited geographic sampling size than Culver et al. (2000), but Culver et al. (2000) had a smaller number of samples. This checklist follows Culver et al. (2000) until more data are available. Overall, more study is needed to resolve subspecies in *P. concolor*.

Family Canidae

Canis latrans: Coyote (Fig. 2)

Canis latrans Say, in James, 1823:168. Type locality is "Engineer Cantonment." Clarified as to about 19.2 km SE present town of Blair, Washington Co., Nebraska by Miller and Kellogg 1955.

Canis ochropus Eschscholtz, 1829:1. Type locality is "California." Name combination. Merriam (1897a) narrowed the type locality to Tracy, San Joaquin County, California.

Canis mearnsi Merriam (1897a:29). Type locality is "Quitobaquito, Pima Co., Arizona."

C. l. mearnsi Nelson, 1932:224: First use of current name combination. See above.

C. l. ochropus Nelson, 1932:224. First use of current name combination. See above.

Of 19 recognized subspecies, two occur in Los Angeles County (Bekoff 1977; Hall 1981; Burgin et al. 2020b): *Canis latrans mearnsi* and *ochropus*. Records for coyote show that it is found throughout the county. *C. l. ochropus* occurs on the coastal foothills of the San Gabriel Mountains, Santa Monica Mountains, and the Los Angeles Basin. *C. l. mearnsi* is found in the Mojave Desert of northern Los Angeles County. Vaughan (1954) found coyotes on both sides of the San Gabriel Mountains but found them to be more common in open areas of sage/chaparral habitats on the Pacific side and pinyon-juniper and Joshua tree habitats on the desert side. Similar to the records for the mountain lion, museum records for the coyote do not provide an accurate description of its distribution in Los Angeles County. Coyote has been recorded from the Ballona Wetlands Ecological Reserve (Johnson 2012) and is found throughout the Los Angeles Basin and other urbanized areas (Koler 1995; Riley et al. 2003; Larson et al. 2020). Mathewson et al. (2008) report that coyotes are found throughout Griffith Park. iNaturalist reports coyotes throughout the Los Angeles Basin in both suburban and urban areas (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 42051). Also, an on-going program sponsored by the University of California Division of Agriculture and Natural Resources "Coyote Catcher" has numerous observations of coyote mapped in the Los Angeles Basin (https://ucanr.edu/sites/CoyoteCacher/).

Taxonomic note: Hall's (1981) maps and marginal records did not provide the detail needed to determine the subspecies occurring in Los Angeles County. Vaughan (1954) states that *mearnsi* is the subspecies in the San Gabriel Mountains. Following Grinnell (1933), it would seem that *ochropus* is the coastal subspecies and *mearnsi* (= *estor* in Grinnell 1933) is the desert subspecies. The limits and ranges of these two subspecies need study.

Urocyon cinereoargenteus: Gray fox (Fig. 3)

Canis cinereo argenteus (Schreber, 1775:pl. 92). Type locality is eastern North America.

Urocyon Baird, 1858a:122. Type species *Canis virginianus* Erxleben (= *Canis cinereo argenteus* Schreber). Proposed as subgenus of *Vulpes*.

Urocyon cinereoargenteus: Rhoads, 1894:524. First use of current name combination.

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Fig. 2. *Canis latrans*: Coyote. Photograph by Lindsay Messett. Used with permission.

Fig. 3. *Urocyon cinereoargenteus*: Gray fox. Photograph by L.L. Master. Courtesy of the American Society of Mammalogists Mammal Image Library.

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U. c. californicus Mearns, 1897:459. Type locality is "San Jacinto Mts., altitude 8,000 feet, Riverside County, California."

Of 16 recognized subspecies, one occurs in Los Angeles County (Burgin et al. 2020b; Fritzell and Haroldson 1982; Hall 1981): *Urocyon cinereoargenteus californicus*. The gray fox is found in a variety of habitats, including shrublands, deciduous and conifer forest and woodlands, and coastal sage scrub and chaparral in the Santa Monica Mountains; San Gabriel Mountains; Verdugo Mountains; San Rafael Hills; Palos Verdes Hills; and Pyramid Lake (Frias et al. 2012; Frizzell and Haroldson 1982). Mathewson et al. (2008) report that they are found throughout Griffith Park. There are a few older records from the Los Angeles Basin, but the urbanized Los Angeles Basin no longer supports habitat for this species. Friesen et al. (1981) reported sightings at Ballona Creek Ecological Reserve based on the literature they reviewed; however, it was not observed or confirmed as present. This species was also not reported as present at the Ballona Creek Ecological Reserve in more recent surveys (Johnson (2012). Elevation records for Los Angeles County range from 5 to 1,376 m.

Urocyon littoralis: Island fox

Vulpes littoralis (Baird, 1858a:143). Type locality is "San Miguel Island", Santa Barbara County, California.
Urocyon littoralis: Merriam, 1888:135. First use of current name combination.
Urocyon catalinae Merriam, 1903:74. Type locality is "Catalina Island, Santa Barbara Islands, California." Name combination.
Urocyon clementae Merriam, 1903:75. Type locality is "San Clemente Island, Santa Barbara Islands, California." Name combination.
U. l. catalinae Grinnell et al., 1937:467. First use of current name combination.
U. l. clementae Grinnell and Linsdale, 1930:154. First use of current name combination.

Of six recognized subspecies, two occur in Los Angeles County (Hall 1981; Moore and Collins 1995): *Urocyon littoralis catalinae* and *clementae*. The island fox is endemic to the California Channel Islands (Moore and Collins 1995). The Santa Catalina Island fox (*U. l. catalinae*) is listed as a Federally Threatened Species and as a State-Listed Threatened Species (CDFW 2021b) and the San Clemente Island fox (*U. l. clementae*) is a State-Listed Threatened Species (CDFW 2021b). The island fox is found in all habitats of the Channel Islands. Records show that *U. l. catalinae* and *U. l. clementae* are found through each of their respective islands.

Vulpes macrotis: Kit fox

Vulpes macrotis Merriam, 1888:136. Type locality is "Riverside, California." More exactly, on the western margin of the San Jacinto Plain in the vicinity of Box Springs, within 10 miles southeast of Riverside. The type locality is in Riverside County (Miller and Kellogg 1955). Merriam (1888) states in the text of the description that the type is from Riverside, San Bernardino County. California.
Vulpes arsipus Elliot, 1903:25. Type locality is "Daggett, San Bernardino County, California." Name combination.
V. m. arsipus Grinnell, 1913:287. First use of current name combination. See above.

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Of the eight recognized subspecies of the kit fox, one occurs in Los Angeles County (McGrew 1979; Burgin et al. 2020b): *Vulpes macrotis arsipus*. The kit fox is found in the desert scrub of the Mojave Desert area of northern Los Angeles County. Vaughan (1954) found kit fox in the San Gabriel Mountains in the Joshua tree belt up to about 1,000 m. Elevation records for Los Angeles County range from 80 to 1,059 m. At one time a second subspecies occurred in Los Angeles County, *V. m. macrotis* (Grinnell 1933; Grinnell et al. 1937). This subspecies seems to have been rare in the 1930s and the last noted observation was in 1903 (Grinnell 1933).

Taxonomic Note: The number of subspecies of kit fox is an open question. Mercure et al. (1993), based on mtDNA, suggested that the kit fox consists of just two subspecies, the San Joaquin Valley subspecies *V. m. muticus* (a Federally-listed Endangered species and a California-listed Threatened species) and a second subspecies that would consist of the other seven recognized subspecies and that would be recognized as *V. m. macrotis*. This lumping of subspecies was previously suggested by Dragoo et al. (1990) based on multivariate morphometric analyses and they suggested that the kit fox is monotypic. More recently Sillero-Zubiri (2009) recognized seven subspecies of kit fox. Hall (1981) considered the kit fox and its eight subspecies as conspecific with the swift fox, *V. velox*. Other authors have also suggested these two may be conspecific (Dragoo et al. 1990). These suggested taxonomic changes have not been followed by subsequent authorities.

Vulpes vulpes: Red fox

Canis vulpes (Linnaeus, 1758:40). Type locality is "Sweden."
Vulpes Frisch, 1775:15. Type species *Canis vulpes* by designation under the plenary powers (Melville and Smith, 1978). *Vulpes*, Frisch (1775) was rejected under International Commission on Zoological Nomenclature (ICZN) Opinion 258 (ICZN 1954), which nullified the names proposed by Frisch (1775) because he did not apply the rules of binomial nomenclature. However, in 1979 the ICZN ruled to conserve *Vulpes* Frisch (1775) and set the type specimen as *Canis vulpes* Linnaeus, 1758 (ICZN 1979).
Vulpes vulpes: Jentik, 1892:90. First use of current name combination.

There are 45 recognized subspecies worldwide and 13 recognized in North America (Lariviere and Pasitschniak-Arts 1996; Burgin et al. 2020b). The red fox in Los Angeles County is not the native subspecies (Lewis et al. 1995). The red fox was introduced to southern California independently from multiple sources including as game for fox hunters, as escapees from fur farms, and possibly as a biological control for California ground squirrel (*Otospermophilus beecheyi*) (Lewis et al. 1995). Vail (1942) described fox farms from the San Bernardino Mountains near Big Bear Lake housing in excess of 5,000 animals. He also described fox farms from Gardena and Redondo Beach. The red fox has been recorded from the Santa Monica Mountains, Eagle Rock, Palos Verdes Peninsula, and the Los Angeles Basin. It is known from the community of Playa del Rey (Johnson 2012). This species is found along the coastal lowlands of southern California (Lewis et al. 1999). iNaturalist shows observations along the county coast from Marina del Rey to San Pedro and the Palos Verdes Peninsula, and one interesting observation in San Fernando (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 42069).

Taxonomic Note: Statham et al. (2014) analyzed nuclear and mtDNA for a global sample of red fox. They suggest that their results support considering the North American

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populations of red fox as a species (*V. fulva*) separate from the Old World populations of red fox (*V. vulpes*). Interestingly, this was the case prior to 1959 (Miller and Kellogg 1955) when Churcher (1959) synonymized the red fox into one species.

Family Ursidae

Ursus americanus: American black bear

Ursus americanus Pallas, 1780:5. Type locality is "Eastern North America."
Ursus californiensis Miller, 1900:250. Type locality is "California." Name combination. Restricted to Sierra Nevada, California by Grinnell (1929).
U. a. californiensis Grinnell, 1929:396. First use of current name combination.

Of 16 recognized subspecies, one occurs in southern California: *Ursus americanus californiensis* (Hall 1981; Lariviere 2001). There are only two museum records for the American black bear in Los Angeles County. However, the California Department of Fish and Wildlife shows that the known range of the American black bear includes the San Gabriel Mountains of Los Angeles County (https://wildlife.ca.gov/Conservation/Mammals/Black-Bear/Black-Bear-Habitat, Accessed 31 January 2020). The population of the American black bear in Los Angeles County is not native to southern California. In the 1930s, the California Department of Fish and Wildlife introduced American black bear into portions of southern California (CDFW 2016). Vaughan (1954) reported that 11 black bears were introduced into the San Gabriel Mountains at "Crystal Lake" in 1933 by the California Department of Fish and Wildlife.

Hall (1981) stated that, following the extirpation of the native grizzly, the American black bear expanded its range into the southern Sierra Nevada, Tehachapi Mountains, and southern Coast Mountain Ranges. Until its introduction by CDFW into southern California, the black bear was only known from northern California (Stephens 1906). iNaturalist reports observations of American black bears from the coastal facing foothills of the San Gabriel Mountains and along the major roads through the San Gabriel Mountains (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 41638). It also reportedly occurs in the Santa Monica Mountains (https://home.nps.gov/samo/learn/nature/upload/samo_mammals_checklist.pdf).

Taxonomic Note: Puckett at al. (2015) using nucleotide polymorphisms and mtDNA from samples of black bear from across North America north of Mexico found that currently recognized subspecies ranges were not consistent with their population clusters based on genetics. They suggest a reevaluation of subspecies of American black bears. Burgin et al. (2020b) does not list subspecies but suggests a reanalysis of the existing recognized 16 subspecies.

Historic note: California grizzly (*Ursus arctos*). The California grizzly bear was once common in the state including Los Angeles County (Stephens 1906; Grinnell et al. 1937) and was the only species of bear in Los Angeles County until its extirpation. Stephens (1906) noted in 1906 that "Grizzly Bears were formerly common in California but are now rare, with the probability of their becoming extinct in the near future." Indeed, the last grizzly bear killed in southern California was shot in lower Tujunga Canyon near Sunland in October of 1916, and the last confirmed sighting in the state was in 1931 in Tulare County (Grinnell et al. 1937).

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Fig. 4. *Taxidea taxus*: American badger. Photograph by B. M. Zinke. Courtesy of American Society of Mammalogists Mammal Image Library.

Family Mustelidae

Mustela frenata: Long-tailed weasel

Mustela frenata Lichtenstein, 1831:pl. 42. Type locality is "Nähe von Mexico" [Ciudad Mexico, Mexico].
M. f. latirostra Hall, 1936:96. Type locality is "San Diego, San Diego County, California."

Of 42 recognized subspecies, one occurs in Los Angeles County (Sheffield and Thomas 1997; Burgin et al. 2020b): *Mustela frenata latirostra*. The long-tailed weasel occurs in a wide variety of habitats, but only those that support its rodent prey. It has been recorded from the Santa Monica Mountains; Griffith Park; Elysian Park; Santa Clarita and Soledad Canyon; Chino Hills State Park; and from the vicinity of Llano in the Mojave Desert. Friesen et al. (1981) reported it as known to occur historically at Ballona Creek Ecological Reserve; however, its presence was not recorded by Johnson (2012). Mathewson et al. (2008) did not detect long-tailed weasel in Griffith Park, but suspected it is still present. Vaughan (1954) noted finding long-tailed weasels in Lytle and San Antonio Canyons in the San Gabriel Mountains. There are older records from the Los Angeles Basin and San Fernando Valley; however, these areas are urbanized and no longer support habitat for this species. Elevation records for Los Angeles County range from 14 to 995 m.

Taxonomic Note: Patterson et al. (2021) has advocated replacing *Mustela* with *Neogale* as the generic name for the long-tailed weasel. This checklist retains the use of *Mustela*.

Taxidea taxus: American badger (Fig. 4)

Ursus taxus (Schreber, 1778:520, fig. 142B). Type locality is "pays des Esquimaux" [land of the eskimos] from Buffon, 1776:243-244.
Ursus labradorius Gmelin, 1788:102. A renaming of *Ursus taxus* Schreber.
Taxidea Waterhouse, 1838:154. Type species [*Ursus*] *Meles labradorius* Gmelin, by original designation.

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Meles jeffersonii Harlan, 1825:309. Type locality "open plains of Columbia [River Valley], sometimes those of Missouri [Valley.]." Name combination.
Taxidea berlandieri Baird, 1858a:205. Type locality is "Llano Estacado, Texas." Name combination.
Taxidea taxus: Rhoads, 1894:524. First use of current name combination.
T. t. jeffersonii Long, 1972:732. First use of current name combination. See above.
T. t. berlandieri J. A. Allen, 1895:256. First use of current name combination. See above.

Of four recognized subspecies, two occur in Los Angeles County (Long 1973; Hall 1981; Burgin et al. 2020b): *Taxidea taxus berlandieri* and *jeffersonii.* The American badger is found in dry shrub, forest, and desert habitats with friable soils. It has been recorded from the Santa Monica Mountains, and from scattered locations in the Los Angeles Basin where there is no longer suitable habitat to support its presence. There are records of *T. t. berlandieri* from the Mojave Desert including the Poppy Reserve, Neenach, Fairmont and one near Lake Los Angeles. There are several records of *T. t. jeffersonii* from Pasadena, South Pasadena, Covina and the Santa Monica Mountains, and the Puente Hills (P. Stapp, CSU Fullerton, pers. comm. March 2022). Vaughan (1954) reported American badger from the pinyon-juniper and Joshua tree belt on the desert slopes of the San Gabriel Mountains. iNaturalist shows observations from the Santa Clarita area, Chatsworth, and the San Gabriel Mountains (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 41789). Elevation records for Los Angeles County range from 15 to 1,417 m.

Family Mephitidae

Mephitis mephitis: Striped skunk

Viverra mephitis (Schreber, 1777:3(17) Pl. 121 (1776)). Type locality is eastern Canada [= Province of Quebec].
Mephitis E. Geoffroy Saint-Hilaire and Cuvier, 1795:183. Type *Viverra mephitis* Schreber, 1777.
Mephitis occidentalis Baird, 1858a:194. Type locality is "Petaluma, California." Name combination.
Mephitis mephitis: J. A. Allen et al., 1902:115. First use of current name combination.
Mephitis occidentalis holzneri Mearns, 1897:461. Type locality is "San Isidro Ranch, Lower California." Narrowed by Grinnell (1933) to within 2 mi United States-Mexico border, 19 mi E Pacific seacoast, Baja California, Mexico.
M. m. holzneri Grinnell, 1933:107. First use of current name combination.

The genus *Mephitis* has had a complicated and interesting taxonomic history (Howell 1902; Hall 1981). Of 13 recognized subspecies, one occurs in Los Angeles County (Hall 1981; Wade-Smith and Verts 1982): *Mephitis mephitis holzneri.* The stripped skunk is found in a wide variety of habitats, including urban/suburban habitats (Rosatte et al. 1990; Bateman and Fleming 2012). In Los Angeles County the striped skunk has been recorded from throughout the Los Angeles Basin; Palos Verdes Hills; Santa Monica Mountains in the vicinity of Glendale and Universal City; Verdugo Mountains; San Rafael Hills; San Gabriel Mountains along Angeles Crest Highway; Santa Clarita; and the Santa Susana Mountains. Friesen et al. (1981) reported it as known to occur at

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Ballona Creek Ecological Reserve and Johnson (2012) confirmed presence using critter cameras. Mathewson et al. (2008) reported that striped skunk is found throughout Griffith Park. Vaughan (1954) reported that striped skunks were common in the citrus belt and vineyards on the Pacific coast slopes of the San Gabriel Mountains. iNaturalist has observations throughout the urbanized area of the Los Angeles Basin (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 41880). Elevation records for Los Angeles County range from 15 to 1,417 m.

Spilogale gracilis: Western spotted skunk

Spilogale gracilis Merriam, 1890a:83. Type locality is "Grand Canyon of the Colorado (altitude 3,500 feet), Arizona, north of San Francisco Mountain."
S. phenax Merriam, 1890b:13. Type locality is "Nicasio, Marin County, California." Type locality in Coconino County (Grinnell 1933). Name combination.
S. g. phenax Grinnell, 1933:105. First use of current name combination. See above.

Of seven recognized subspecies, one occurs in Los Angeles County (Hall 1981; Verts et al. 2001): *Spilogale gracilis phenax*. The western spotted skunk has been recorded from the San Gabriel Mountains; Santa Monica Mountains; West Hollywood; Glendale; Palos Verdes Hills; Griffith Park; Baldwin Hills; San Rafael Hills; San Jose Hills; the Los Angeles Basin; and two locations in the Mojave Desert: one at Palmdale and one at Love Joy Buttes. Vaughan (1954) reported that the western spotted skunk was commonly found in rocky sage scrub habitat on the Pacific slope of the San Gabriel Mountains between 300 and 1200 m elevation. The elevation range for Los Angeles County is 29 to 1,417 m. McDonough et al. (2021) revised the spotted the skunk in North America and determined that there are seven rather than five species. However, the western spotted skunk and its subspecies were not changed.

Family Procyonidae

Bassariscus astutus: Ringtail (Fig. 5)

Bassaris astuta (Lichtenstein, 1830:119.) Type locality "Mexico City," exact locality unknown.
Bassariscus astutus: Coues, 1887:516. Renaming of *Bassaris*. Type species is *Bassaris astuta* Lichtenstein. First use of current name combination.
B. a. octavus Hall, 1926:39. Type locality is "San Luis Rey River, 1700 feet altitude, near Escondido, San Diego County, California."

Of 14 recognized subspecies, one occurs in Los Angeles County (Hall 1981; Poglayen-Neuwall and Toweill 1988; Burgin 2020b): *Bassariscus astutus octavus*. There are only a few records of the ringtail from Los Angeles County. It has been recorded from the Santa Monica Mountains; Hollywood Hills; Griffith Park; southern San Gabriel Mountains; San Antonio Canyon; Mt. Wilson; and San Fernando. Koler (1995) reports ringtail from Millard Canyon in Pasadena. iNaturalist reports observations from the coastal foothills of the San Gabriel Mountains and one from Santa Monica (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 41674). Vaughan (1954) found ringtail locally common in rocky chaparral habitat near

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Fig. 5. *Bassariscus astutus*: Ringtail. Photograph by D.T. Wyatt. Courtesy of American Society of Mammalogists Mammal Image Library.

water on the Pacific slope of the San Gabriel Mountains, but not on the desert slopes. The elevation range for Los Angeles County is 265 to 1,500 m.

Procyon lotor: Northern raccoon

Ursus Lotor (Linnaeus, 1758:48). Type locality is "Americae maritimis" restricted to Pennsylvania by Thomas (1911:140).
Procyon Storr, 1780:35. Type species *Ursus lotor* Linnaeus, by monotypy.
Procyon Psora Gray, 1842:261. Type locality is "Sacramenta [Sacramento Co.] California." Name combination.
P. l. psora Grinnell, 1933:98. First use of current name combination. See above.

Of 20 recognized subspecies, one occurs in Los Angeles County (Burgin et al. 2020b; Kays 2009): *Procyon lotor psora*. There are very few museum records for the northern raccoon from Los Angeles County. Records include the Santa Monica Mountains; San Gabriel Mountains; Griffith Park; and Elysian Park. Johnson (2012) reports raccoon at the Ballona Creek Ecological Reserve. This species has become tolerant of urbanization (Lotze and Anderson 1979; Ordeñana et al. 2010) and can be found throughout the Los Angeles Basin. Mathewson et al. (2008) report that the northern raccoon is found throughout Griffith Park. Vaughan (1954) found that the northern raccoon was the most common carnivore in the San Gabriel Mountains and occurred up to an elevation of 2,400 m. iNaturalist shows observations from nearly the entire Los Angeles Basin including the coastal foothills of the San Gabriel Mountains and a few from the Mojave Desert

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(https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 41663). Elevation records for Los Angeles County range from 42 to 1,533 m.

Kays (2009) recognized 20 subspecies but stated that the taxonomy of the mainland North American species need revision.

Order Artiodactyla

Family Suidae

Sus domesticus: Eurasian wild pig

S. domesticus Erxleben 1777:178. Type locality unknown.

The Eurasian wild pig was brought to North America from Europe in the 16th Century (Seward et al. 2004; McCann 2012). The Eurasian wild pigs roaming in Los Angeles County and greater southern California are the result of escapees from domestic ranching and from deliberate introductions for hunting. These animals cause extensive damage to natural and agricultural ecosystems in the U.S. (Seward et al. 2004 and sources cited therein; McCann 2012). There is only one museum record for the Eurasian wild pig in Los Angeles County. According to the California Department of Fish and Wildlife, the range for the Eurasian wild pig in Los Angeles County includes the Santa Monica Mountains and the San Gabriel Mountains (CDFW 2017). Introduced to Santa Catalina Island in the 1930s (Schuyler et al. 2002), this species has since been eradicated to protect the island's natural habitats (https://www.catalinaconservancy.org/index.php?s = wildlife&p = non_native_animals). Eurasian wild pigs also at one time occurred on San Clemente Island but have since been eliminated (Sweitzer 1998).

Family Cervidae

Odocoileus hemionus: Mule deer (Fig. 6)

Cervus hemionus (Rafinesque, 1817b:436). Type locality is near mouth of the Big Sioux River, South Dakota.
Odocoileus hemionus: Merriam, 1898:100. First use of current name combination.
Cervus macrotis var. *Californicus* Caton, 1876:464. Type locality is near Gaviota Pass, 40 mi W Santa Barbara, Santa Barbara County, California.
Dama h[*emionus*] *californica* J. A. Allen, 1902:20.
O. h. californicus Thompson, 1898:286. First use of current name combination. See above.

Of eight recognized subspecies, one occurs in Los Angeles County: *Odocoileus hemionus californicus* (Burgin et al. 2020b). Records for mule deer in Los Angeles County are from the San Gabriel Mountains, plus a record from Elysian Park and one from Lincoln Park. Mathewson et al. (2008) report detections of mule deer in Griffith Park. Vaughan (1954) found mule deer plentiful on both the Pacific and desert slopes of the San Gabriel Mountains. iNaturalist shows observations from the Santa Monica; Santa Susana; and San Gabriel Mountains; as well as the Verdugo Mountains; Griffith Park; Hacienda Hills; Catalina Island; and a few scattered observations from the Mojave Desert (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 42220). The species occurs throughout the county in suitable habitat, which is mainly in the foothills and mountains. Its elevational range is 115 to 1,647 m.

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Fig. 6. *Odocoileus hemionus*: Mule deer. Photograph by Ann Berkley. Courtesy of the U.S. Forest Service. Used with permission.

Santa Catalina Island mule deer are not native to the island. They were imported to the island by CDFW between 1928 and 1932 (Longhurst et al. 1952; Dvorak and Catalano 2016). The introduced mule deer were transplanted from Modoc and Placer Counties (Longhurst et al. 1952) and the herd is actively managed by the Catalina Island Conservancy (https://www.islapedia.com/index.php?title = *_Deer:_Santa_Catalina_Island) along with non-native bison, to minimize damage to the island's native plant communities (Knapp 2014).

Taxonomic Note: In 1960 the ICZN (1960) ruled in Opinion 581that *Dama* Zimmerman (1777) was not an available name and so retained the use of the generic name *Odocoileus* Rafinesque (1832) for North American deer and retained *Dama* Frisch (1775) for the genus of European roe deer.

Mule deer have a complex taxonomic history, which is detailed in Cowan (1936). Anderson and Wallmo (1984) recognize 10 subspecies based on Hall (1981) who recognized 11 subspecies. The number of mule deer subspecies; however, is uncertain (Latch et al. 2009; 2014; Gutiérrez et al. 2017). These studies have suggested that *O. hemionus*, as currently recognized, is polyphyletic. For example, these studies present evidence that the black-tailed deer *O. h. columbianus* should be separated from *O. hemionus* as a separate species (Latch et al. 2009; Groves and Grubb 2011; Gutiérrez et al. 2017). However, Cowan (1936) synonymized the two species (*O. columbianus* and *O. hemionus*) based on reports of widespread hybridization in the wild. More research is needed to resolve the species and subspecies issues in *Odocoileus hemionus*.

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Family Antilocapridae

Antilocapra americana: Pronghorn

Antilope Americanus (Ord, 1815:292.) Type locality is the plains and highlands of Missouri River.
Antilocapra americana Ord, 1818:149. Renaming of *Antelope Americanus*. First use of current name combination.
Antilocapra americana americana Grinnell 1913:368. First use of current name combination. See above.

Burgin et al. (2020b) recognize three subspecies following Byers (2011). However, Hall (1981) and O'Gara (1978) recognize five. One subspecies is found in Los Angeles County (Byers 2011; Hall 1981; O'Gara 1978): *Antilocapra americana americana*. Willet (1944) reported that pronghorn were present in the Antelope Valley 10 years previously but may have been extirpated by 1944.

There are four records of pronghorn from Los Angeles County in the Mojave Desert area near the California Poppy Reserve. Elliot (1904) reported that Heller observed a herd of 30 pronghorn at the western edge of the Antelope Valley near the eastern base of the Tehachapi Mountains, and further stated that this herd was the remnant of a herd of hundreds formerly inhabiting this area. Stevens (1906) stated that their numbers were diminishing in the state. CDFW shows this area of Los Angeles County as part of the range of the pronghorn in the state (https://wildlife.ca.gov/Conservation/Mammals/Pronghorn, accessed July 3, 2021). iNaturalist shows pronghorn observations in and around Quail Lake (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 42429).

Family Bovidae

Ovis canadensis: Bighorn sheep (Fig. 7)

Ovis canadensis Shaw, 1804:pl. 610. Type locality is Exshaw, Alberta, Canada.
Ovis nelsoni Merriam, 1897b:218. Type locality is "Grapevine Mountains, boundary between California and Nevada, just south of latitude 37°."
O. c. nelsoni Lydekker, 1898:208. First use of current name combination. See above.

The number of subspecies reported in the literature varies from seven (Hall 1981; Shackleton 1985) to five (Burgin et al. 2020b; Valdez 2011) to three (Weyhausen and Ramey 2000; Weyhausen et al. 2005; Buchalski et al. 2016). The latter is followed in this checklist. One subspecies occurs in Los Angeles County: *Ovis canadensis nelsoni*. Desert bighorn sheep (*Ovis canadensis nelsoni*) is a California Fully Protected Species, with the exception of legal hunting conducted in compliance with California Code of Regulations 14 CCR 362. Bighorn sheep are found in the San Gabriel Mountains of Los Angeles County. iNaturalist show observations mostly in the southern San Gabriel Mountains, south of Highway 2, centered around Mt. San Antonio (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 42391).

Other Bovidae. There are two other species in this family that occur or occurred as wild populations in Los Angeles County, but their distribution in the county is limited to Santa Catalina Island: *Bos bison* (American bison) and *Antilope cervicapra* (blackbuck), and one species that previously occurred on Santa Catalina Island until the early 2000's *Capra*

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Fig. 7. *Ovis canadensis*: Bighorn sheep. Photograph by F. Duncan. Courtesy of the U.S. Forest Service. Used with permission.

hircus (domestic goat). American bison were introduced to the island in the 1920's for a movie shoot and are currently maintained in small numbers (<200) to minimize damage to the island's habitat (Longhurst et al. 1952; Sweitzer et al. 2005). For many years this species was known as *Bison bison* (Hall 1981; Meager 1986).

A small herd of blackbuck antelope (*Antelope cervicapra*) still live on Santa Catalina Island near the airport. These individuals are descendants of blackbuck brought to the island in 1967 by the Santa Catalina Island Company (http://www.californiaforvisitors.com/catalina/about/fauna/antelope.htm). The blackbuck is native to India (Groves 2011).

The date when domestic goats were introduced to Santa Catalina Island is not known, but they were well established by 1820 (Coblentz 1977). They were eradicated by 2002 as part of broader control of non-native herbivores (Campbell and Donlans 2005; Sweitzer et al. 2005; https://www.catalinaconservancy.org/index.php?s = wildlife&p = non_native_animals). Domestic goats also previously occurred on San Clemente Island but were eradicated in 1991

(https://en.wikipedia.org/wiki/San_Clemente_Island_goat; Seward 1991). When domestic goats were introduced to San Clemente Island is not definitely known but appears to have some time in the mid-nineteenth century (Johnson 1975).

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Order Chiroptera

Family Phyllostomidae

Choeronycteris mexicana: Mexican long-tongued bat

Glossophaga (*Choeronycteris*) *mexicana* (Lichtenstein in Tschudi, 1844:72.) Type locality is "Mexico".

Choeronycteris mexicana: Peters, 1865:354. Elevation of *Choeronycteris* to generic status. First use of current name combination.

The Mexican long-tongued bat is monotypic (Hall 1981; Arroyo-Cabrales et al. 1987), and it is a California Species of Special Concern (CDFW 2021b). This species is most likely a rare visitor to Los Angeles County. There is one museum record from Los Angeles County (Constantine 1998), unfortunately, the specimen tag was lost in transit, so the exact locality is unknown. That specimen was obtained in 1988. There are no CNDDB records for this species in Los Angeles County. This species is common in Baja California and northern Mexico. It has been recorded as far north as Ventura County, but most records are from the southernmost part of the state in San Diego County (Tremor et al. 2017; Constantine 1998). The Mexican long-tongued bat roosts in caves, mines, and other structures (Arroyo-Cabrales et al. 1987). It naturally occurs in a variety of habitats ranging from desert scrub to pinyon-juniper habitats. This species was not previously reported by McLaughlin (1959).

Macrotus californicus: California leaf-nosed bat

Macrotus Californicus Baird, 1859:116. Type locality is "Fort Yuma, California" narrowed to on the right bank of the Colorado River opposite the present town of Yuma, Arizona, and now in Imperial County, California by Miller and Kellogg (1955).

The California leaf-nosed bat is monotypic (Hall 1981; Anderson 1969) and it is a California Species of Special Concern (CDFW 2021b). The museum records for the California leaf-nosed bat in Los Angeles County are from the Santa Susana Mountains near Chatsworth, Owensmouth (now Canoga Park), and Iverson Ranch. These date from prior to 1950, and this species is considered extirpated in the county (Brown and Berry 2005). Extant populations in California occur now mostly in scattered mines and caves in the Mojave Desert of Riverside and San Bernadino Counties and along the Colorado River in desert shrub in areas of rocky, rugged terrain with mines and caves where it uses caves and mines as roost sites (Hall 1946; Vaughan 1959; Bradshaw 1961; Anderson 1969). Constantine (1998) reported the presence of *M. californicus* in caves in Los Angeles County; however, these were originally visited in the 1940's and 1950's and subsequent visits in the 1990's found no bats present (Brown and Berry 2004; 2005).

Family Molossidae

Eumops perotis: Western mastiff bat

Molossus Perotis (Schinz, 1821:870). Type locality is "Brazil, Rio de Janiero, Campos do Goita Cazes, Villa Sao Salvador" (Koopman, 1993:234).

Molossus californicus Merriam, 1890c:31. Type locality is "Alhambra, Los Angeles County, California." Name combination.

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Promops perotis: Thomas, 1901:191(not *Promops* Gervais, 1855). Name combination.
Eumops perotis: Miller 1906:85. First use of current name combination.
E. p. californicus Sanborn, 1932:351. First use of current name combination. See above.

Of two recognized subspecies, one occurs in Los Angeles County (Burgin et al. 2020b; Best et al. 1996; Hall 1981): *Eumops perotis californicus*. The western mastiff bat is a California Species of Special Concern (CDFW 2021b). There are many museum records for the western mastiff bat from throughout the Los Angeles Basin from the San Gabriel Mountains to San Pedro. These museum records from the Los Angeles Basin are not unexpected, as this species is known to roost in man-made structures and inhabited areas (Howell 1920a; 1920b; Best et al. 1996). This species has recently been acoustically recorded at several locations in the Angeles National Forest including south fork of San Gabriel Creek, Mill Creek, and Big Tujunga Canyon Bridge (United States Forest Service Angeles National Forest (ANF), A. Berkely pers. comm. 2021), and also in Santa Clarita along the Interstate-5 corridor (J. Carpenter, pers. comm. 2022). Brown and Berry (2005) acoustically recorded this species in the Santa Monica Mountains National Recreation Area (SMMNRA). The CNDDB did not add any additional localities for this species in the county. This species occupies a wide variety of natural habitats including conifer and deciduous woodlands, sage scrub, chaparral, desert scrub, and urban habitats (Best et al. 1996). In natural areas it roosts in crevices in rocks that form vertical or nearly vertical cliffs, or that are situated on steep slopes. It has also adapted to manmade structures, and it is known to roost in buildings in place of crevices (Best et al. 1996; Howell 1920a; Pierson and Rainey 1998). It has even been documented to roost in palm trees (J. Carpenter, pers. comm. 2022). However, its distribution is roost limited because roost locations must have vertical faces that allow the bats to drop vertically a minimum of 2 to 3 m to gain flight speed (Vaughan 1959; Best et al. 1996). Elevational range in Los Angeles County is 26 to 1,417 m. This species is also known as the western bulldog bat and western bonneted bat. *E. p. californicus* is separated from the nominate subspecies (*E. p. perotis*) by all of Central America (Moras and Lim 2019; Burgin et al. 2020b). Further research may demonstrate that *E. p. californicus* is a separate species.

Nyctinomops femorosaccus: Pocketed free-tailed bat

Nyctinomus femorosaccus (Merriam, 1889:23). Type locality is "Agua Caliente [Palm Springs], Colorado Desert, California."
Nyctinomops femorosaccus: Miller, 1902:393. Type species is *Nyctinomus femorosaccus* Merriam, 1889, by original designation. First use of current name combination. See above.

The pocketed free-tailed bat is monotypic (Hall 1981; Kumirai and Knox Jones, Jr. 1990) and is a California Species of Special Concern (CDFW 2021b). There are a few museum records for the pocketed free-tailed bat from Los Angeles County including Ken Malloy Regional Park; a residential area in Inglewood; a residential area in the Los Angeles Harbor; Azusa; and Covina. It has also been acoustically recorded at Big Tujunga Reservoir (S. Norton pers. comm. 2022) and from several locations in the Angeles National Forest (A. Berkely pers. comm. 2022). The pocketed free-tailed bat occurs in a variety of arid habitats in southern California ranging from pinyon-juniper woodlands to alkali desert scrub, to Joshua tree woodlands, and palm oases (Kumirai and Knox Jones, Jr. 1990). It is strongly

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associated with rocky areas with high cliffs or rock outcrops. It roosts in caves, tunnels, mines, and rock crevices, but it is also known to roost under roof tiles (Kumirai and Knox Jones, Jr. 1990). Elevational range in Los Angeles County is 14 to 700 m. This species was not previously reported by McLaughlin (1959).

Nyctinomops macrotis: Big free-tailed bat

Nyctinomus macrotis (Gray, 1839:5). Type locality is "Cuba," from the " the interior of the island, where it was found in the hollow of a tree" (Carter and Dolan, 1978:89).
N [*yctinomops*] *macrotis*: Miller, 1902:393. First use of current name combination. See above.

The big-free tailed bat is monotypic (Hall 1981; Milner et al. 1990) and is a California Species of Special Concern (CDFW 2021b). There are several museum records for the big free-tailed bat from Los Angeles County including downtown Los Angeles; Inglewood; Burbank; Long Beach; and Azusa. An adult male was found at a high-rise office building in 2011in Santa Monica (J. Carpenter, pers. comm. 2022). This species has also been recorded acoustically on Santa Catalina Island (Brown pers. comm. 2022). The CNDDB (CDFW 2021a) provides one additional location in Pomona. The big free-tailed bat occupies areas characterized by rugged and rocky terrain, particularly rocky cliffs in desert scrub habitats, but can also be found in oak and pine forests. It is known to roost in buildings and in ponderosa pines, Douglas fir, and desert shrubs (Milner et al. 1990). Elevational range in Los Angeles County is 10 to 263 m.

Tadarida brasiliensis: Brazilian free-tailed bat

Nyctinomus brasiliensis (Geoffroy Saint-Hilaire, 1824:343). Type locality is "Curityba", Parana, Brazil (Shamel, 1931:4).
Molossus mexicanus Saussure,1860:283. Type locality is Cofre de Perote, 13,000 feet, state of Veracruz, Mexico as determined by Benson, 1944.
Nyctinomus mexicanus: Bailey, 1905:215. Name combination.
Tadarida brasiliensis: Thomas, 1920:222. First use of current name combination.
Tadarida mexicana: Miller, 1924:86. Name combination.
T. b. mexicana Schwartz, 1955:108. First use of current name combination. See above.

Of nine recognized subspecies, one occurs in Los Angeles County (Hall 1981; Wilkins 1989; Burgin et al. 2020b): *Tadarida brasiliensis mexicana*. There are museum records for the Brazilian (aka Mexican) free-tailed bat from throughout the Los Angeles Basin. There are also museum records from the Santa Monica Mountains; San Gabriel Mountains and the foothill communities; Lake Castaic, and Soledad Canyon; Santa Catalina Island; and San Clemente Island. It is reported to be one of the more common species in the SMMNRA by Brown and Berry (2005) as determined by acoustic surveys. It has been acoustically reported on both Santa Catalina and San Clemente Islands (Brown and Rainey 2018). Remington and Cooper (2014) report this species present in Griffith Park. The species has been acoustically detected from localities throughout the Angeles National Forest (A. Berkely pers. comm. 2021). *Tadarida brasiliensis* is not tracked by the CNDDB because it is common and widespread. The Brazilian free-tailed bat uses a wide variety of habitats from sea level up through mixed conifer forests and is considered relatively well adapted to (and

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commonly detected in) urban environments. It roosts in caves and man-made structures, such as bridges and attics (Wilkins 1989), and has been found to roost in palm trees and cliff swallow mud nests (J. Carpenter, pers. comm. 2022).

Family Vespertilionidae

Aeorestes cinereus: Hoary bat

Vespertilio linereus (Palisot de Beauvois, 1796:18). (Spelling corrected to *cinereus* before distribution, Baird et al. 2015). Type locality is Philadelphia, Pennsylvania.
Aeorestes Fitzinger, 1870:427; part; type species *Vesp. villosissimus* (É. Geoffroy St.-Hilaire, 1806) by original designation.
Lasiurus cinereus: H. Allen, 1864:21. Name combination.
Atalaphia cinerea: True, 1884:602. Name combination.
Nycteris cinerea: Hall, 1981:226. Name combination.
L. c. cinereus Hall and Knox Jones Jr., 1961:95. See above.
A[*eorestes*] *cinereus* Baird et al. 2015:1266. First use of current name combination.

Baird et al. (2015) raised all three subspecies of *Lasiurus cinereus* (*L. c. cinereus*, *L. c. semotus*, and *L. c. villosissimus*) to species level status; therefore, the hoary bat is now monotypic, and no subspecies are recognized (Hall 1981; Shump and Shump 1982a; Baird et al. 2015). The hoary bat has been recorded from throughout the Los Angeles Basin by museum specimens. There are a few museum records for the Santa Monica Mountains and the San Gabriel Mountains from the lower elevation foothills. Remington and Cooper (2014) reported this species in Griffith Park based on acoustic surveys. In 2006, a salvaged specimen was collected on Santa Catalina Island; since that time, Brown and Rainey (2018) have also recorded this species on Santa Catalina Island based on acoustic surveys and museum records. This species is not tracked by the CNDDB. Reports in iNaturalist show the same general distribution as the museum records, but many of these observations are more current and include observations from 2021 (https://www.inaturalist.org/observations?place_id = 962&subview = map&taxon_id = 40523). This species has been acoustically recorded throughout the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) reported finding this species on both the Pacific and desert slopes of the San Gabriel Mountains. The hoary bat roosts in medium to large trees in areas with dense leaf coverage, generally 3-5 m above the ground, but is also known to roost in shrubs and sometimes close to the ground (Shump and Shump 1982a). It will also roost in ornamental trees in parks (J. Carpenter, pers. comm. 2022). It occupies a wide variety of habits and seems limited only by suitable roost sites (Shump and Shump 1982a). This species was reported in McLaughlin (1959) as *Lasiurus cinereus*. The revision by Baird et al. (2015) placing the hoary bat in the genus *Aeorestes* has been subject to debate, see Novae et al. (2018) and Baird et al. (2017 and 2021).

Antrozous pallidus: Pallid bat

V[*espertilio*] *pallidus* (LeConte, 1856:437). Type locality is "El Paso, El Paso Co., Texas." Type locality set by Baird 1858b.
Antrozous pallidus: H. Allen 1864:68. First use of current name combination.
A. p. pacificus Merriam, 1897c:180. Type locality is "old Fort Tejon, Cañada des las Uvas, [Kern Co.] California."

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Of six recognized subspecies, one occurs in Los Angeles County (Hall 1981; Hermanson and O'Shea 1983; Burgin et al. 2020b): *Antrozous pallidus pacificus*. The pallid bat is a California Species of Special Concern (CDFW 2021b). The pallid bat has been recorded from the Los Angeles Basin as far south as downtown Los Angeles and Culver City; the San Fernando Valley; Santa Clarita; Lake Castaic; Soledad Canyon; San Gabriel Mountain foothills in the San Gabriel Valley; Simi Valley; one record from Santa Catalina Island; and a single record from the Angeles Crest Highway and Lake Hughes. Many of the records from the center of the Los Angeles Basin are older and these areas no longer support suitable habitat for the pallid bat. This species has been recorded acoustically from throughout the Angeles National Forest (A. Berkley pers. comm. 2021). Brown and Berry (2005) acoustically recorded this species in the SMMNRA. Vaughan (1954) reported that the pallid bat may be the most common and characteristic bat of the citrus belt on the Pacific slope of the San Gabriel Mountains. However, this species has become rare in coastal southern California (Milner and Stokes 2005). The CNDDB (CDFW 2021a) tracks this species but does not provide any additional locations. The pallid bat occupies a variety of habitats including grasslands; shrublands; woodlands; deserts; and conifer forests. It prefers roosting in rocky outcrops but is known to roost in caves; rock crevices; mines; hollow trees; buildings; bridges; culverts; cliff swallow nests; and palm trees (Hermanson and O'Shea 1983; J. Carpenter, pers. comm. 2022). Elevational range is 3 to 1,417 m.

Corynorhinus townsendii: Townsend's big-eared bat (Fig. 8)

Vespertilio megalotis (Rafinesque, 1818:446). Type locality is "The lower parts of the Ohio" River, probably in southern Indiana and Illinois or Western Kentucky in the region between the Wabash and the Green Rivers (Miller and Kellogg 1955).
Plecotus Townsendii (Cooper, 1837:73, pl. 3, Fig. 6). Type locality is "Columbia River." Restricted by Handley (1959) to Fort Vancouver, Clark Co., Washington
Corinorhinus Townsendi: Dobson, 1875:356. First use of current name combination.
Plecotus [*Corinorhinus*] *macrotis* Dobson, 1878:180. Placed *Corynorhinus* as a subgenus of *Plecotus*.
Corynorhinus megalotis G. M. Allen, 1916:338. Name combination.
Plecotus (*Corynorhinus*) [*townsendii*]: Handley, 1959:96.
Corynorhinus townsendii: Tumlison and Douglas, 1992:281. Re-elevation of subgenus *Corynorhinus* to generic status.
Corynorhinus macrotis townsendii Miller, 1897:53. See above.
Corynorhinus megalotis townsendii G. M. Allen, 1916:344. See above.
C. t. townsendii Handley, 1955:147. First of current name combination. See above.

Of five recognized subspecies, one occurs in Los Angeles County: *Corynorhinus townsendii townsendii* (Hall 1981; Handley 1959; Kunz and Martin 1982; Burgin et al. 2020b). Townsend's big-eared bat is a California Species of Special Concern (Pierson and Rainey 1998; CDFW 2021b). Townsend's big-eared bat has been recorded from Kagel Canyon (north of San Fernando); Soledad Canyon; Acton; Pine Canyon (along the northeastern foothills of the San Gabriel Mountains); vicinity of Llano; and Santa Catalina and San Clemente Islands. However, the museum records for this species all date from the 1940's or earlier. It has more recently been acoustically recorded from Santa Catalina Island, where there is a breeding population (Brown pers. comm. 2022). The CNDDB (CDFW 2021a), provides no additional localities. This species has been acoustically

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Fig. 8. *Corynorhinus townsendii*: Townsend's big-eared bat. Photograph by Patricia Brown. Used with permission.

detected from two locations in the Angeles National Forest (A. Berkely pers. comm. 2021). Brown and Berry (2005) speculate that of the bats they did not detect in the SMMNRA this species is the most likely to occur. This species emits low intensity echolocation signals and is often not detected in acoustic surveys. Townsend's big-eared bat is found in a wide range of habitats from desert scrub to coastal scrub to montane forests (Andersen et al. 2018). Its roost sites are located in caves, cliff faces, rocky ledges, mines, tunnels, buildings, or other human-made structures (Kunz and Martin 1982).

Dasypterus xanthinus: Western yellow bat

Nycticejus Ega (Gervais, 1856:73). Type locality is "*Ega*, ville du Brasil," in the state of Amazonas.
[*Lasiurus* (*Dasypterus*)] *ega*: Trouessart, 1904:86. Name combination.
D[*asypterus*]. *xanthinus*: Miller, 1902:392. First use of current name combination.
Lasiurus xanthinus: Baker et al., 1988:11. Name combination.
Dasypterus ega xanthinus Thomas, 1897:544. Type locality is "Sierra Laguna, Lower [Baja] California."
Lasiurus ega xanthinus Handley, 1960:474. See above.
Dasypterus xanthinus: Baird et al. 2015:1268. Re-elevation to generic status of *Dasypterus*.

The western yellow bat is currently considered monotypic (Hall 1981; Kurta and Lehr 1995; Baird et al. 2015) and is a California Species of Special Concern (CDFW 2021b). The

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most recent revision of the genus (Baird et al. 2015) once again placed the western yellow bat in the genus *Dasypterus*. This change has been subject to recent scientific debate Novae et al. (2018) and Baird et al. (2017; 2021). There are a few museum records for the western yellow bat in Los Angeles County: one each in the vicinity of downtown Los Angeles; Huntington Park; Glendale; Glendora; Azusa; and Pomona. The CNDDB (CDFW 2021a) provides no additional locations. The yellow bat is found in the desert scrub habitats in areas with yucca, creosote, and opuntia where it is mostly associated with palms. There are no palm oases in Los Angeles County, but there are many planted palms that provide potential roosting spots. It is a tree roosting bat, generally hanging from the midrib of a leaf or palm frond by its hind feet. It commonly roosts in the dead fronds of palm trees (Kurta and Lehr 1995). Outside of the deserts it has been documented to utilize riparian habitats (Tremor et al. 2017; J. Carpenter, pers. comm. 2022). There needs to be more research into the ecology and roosting habitats of this species in southern California. This species was not previously reported in McLaughlin (1959).

Eptesicus fuscus: Big brown bat

Vespertilio fuscus (Palisot de Beauvois, 1796:18). Type locality is "Les environs de Philadelpia," Pennsylvania.

Eptesicus fuscus: Méhely, 1900:206. First use of current name combination.

Eptesicus pallidus Young, 1908:408. Type locality is "Boulder, Colorado." Name combination.

E. f. bernardinus Rhoads, 1902:619. Type locality is "San Bernardino Valley (near San Bernardino) Cal [ifornia]." First use of current name combination.

Of 11 recognized subspecies, one occurs in Los Angeles County (Engles 1936; Hall 1981; Kurta and Baker 1990; Burgin et al. 2020b): *Eptesicus fuscus bernardinus*. There are records for the big brown bat from throughout the Los Angeles Basin; Santa Monica Mountains; San Gabriel Mountains; and coastal and desert foothills; and some records from the Mojave Desert area of northern Los Angeles County. Brown and Berry (2005) netted and acoustically recorded this species in the SMMNRA. Remington and Cooper (2014) acoustically reported this species in Griffith Park. This species has been acoustically recorded from locations throughout the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) found big brown bats on the Pacific slopes and desert slopes of the San Gabriel Mountains. He noted that they occur up to 2,400 m on the Pacific slope and up to 1,460 m on the desert slope. The big-brown bat is found in nearly all habitats and is known to roost in hollow trees, caves, openings in rock ledges, cliff swallow nests, and palm trees. and buildings and other man-made structures (Kurta and Baker 1990). It has been declining in southern California and may be intolerant of fragmentation of its foraging habitat (J. Carpenter, pers. comm. 2022; Remington 2000). The CNDDB does not track *Eptesicus fuscus*.

Euderma maculatum: Spotted bat

Histiotus maculatus (J.A. Allen, 1891:195). Type locality is "Piru, in the western part of Ventura County, California".

Euderma H. Allen, 1892:467. Type species is *Histiotus maculatus* J.A. Allen, 1891. By original designation.

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Euderma maculata: H. Allen, 1894:61. Name combination.
Euderma maculatum: Handley, 1959:122. First use of current name combination.

The spotted bat is monotypic (Hall 1981; Watkin 1977; Burgin et al. 2020b). There are no museum records for this species from Los Angeles County. I have included this species because in the records was reported as a dead individual "caught on a fence"; which is a reference to the original description by J.A. Allen (1891). This specimen is included in the CNDDB (CDFW 2021a). The CNDDB record discusses the location as follows, "location given as Castaic Cr[eek], in Ventura co at 296 m elevation. Castaic Cr[eek] is in Los Angeles Co, but elevation is correct. The Lat[itude]-Long[itude] given is at the mouth of Piru Cr[eek], but elevation is wrong" (CDFW 2021c). A 1992 letter describes the type locality as probably near the mouth of Castaic Creek in Los Angeles County (Rainey 1992). This is the location of type specimen as described by J.A. Allen (1891). The type specimen is described in Ventura County; however, because there is some uncertainty as to the exact location, I have included it on this checklist. The CNDDB (CDFW 2021a) also provided another record in Los Angeles County. This second CNDDB record is from an acoustic recording from Malibu Creek State Park (Brown and Berry 2005). Brown and Berry (2005) have acoustically recorded this species at several locations in SMMNRA. This species is very rare in museum collections. The spotted bat is found in a variety of habitats from deserts and grasslands to woodland and conifer forests (Watkins 1977).

Lasionycteris noctivagans: Silver-haired bat

Lasionycteris [*noctivagans*]: Peters, 1866:648. Type species *Vespertilio noctivagans* (LeConte). Type locality is eastern United States.

The silver-haired bat is monotypic (Hall 1981; Kunz 1982; Burgin et al. 2020b) and is a California Species of Special Concern. There are only a few museum records for this species in Los Angeles County including one record each from the San Fernando Valley; La Canada/Flintridge; Santa Monica; San Rafael Hills; Long Beach; Lakewood; and Cerritos. This species has been acoustically recorded from one location (South Fork of the San Gabriel Creek, vicinity of Mt. Wilson) in the Angeles National Forest (A. Berkely pers. comm. 2021). Although not detected by acoustic signals, Brown and Berry (2005) speculate that this species may also occur seasonally in the SMMNRA. This species is tracked by the CNDDB (CDFW 2021a), but the CNDDB provides no additional locations in Los Angeles County. The silver-haired bat is found in coniferous forests; foothill woodlands; pinyon-juniper woodlands; riparian habitats with nearby open brushy areas; ponds; or streams. It roosts under loose tree bark; especially of willow; maple; and ash trees; and in hollow trees; snags; rock crevices; caves; and bird nests. It may also roost in open sheds and garages but roosting in buildings is rare (Kunz 1982). This species was not previously reported in McLaughlin (1959).

Lasiurus borealis: Eastern red-bat

Vespertilio borealis (Müller, 1776:20). Type locality is New York.
Lasiurus Gray, 1831:38. Type species *Vespertilio borealis* (Muller, 1776).
Lasiurus borealis: Miller, 1897: 105. First use of current name combination.

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The eastern red bat has recently been identified from five locations in Southern California including a female from the City of Long Beach based on genetic analysis of tissue samples (Brown and Rainey in prep. 2022). This species was identified acoustically on Santa Catalina Island. Based on this information it appears more research into the distributions and possible sympatry of the eastern and western red bat is needed. This will require genetic analysis of museum specimens listed as western red bats.

Lasiurus frantzii: Western red bat

Vespertilio borealis (Müller, 1776:20). Type locality is New York.
Atalapha Frantzii Peters, 1870:908. Type locality is "Costa Rica." Name combination.
Lasiurus Gray, 1831:38. Type species *Vespertilio borealis* (Muller, 1776).
Atalapha teliotis H. Allen, 1891:5; type locality unknown, but probably southern California. Name combination.
Nycteris borealis Hollister, 1910:30. Name combination.
Lasiurus borealis teliotis Miller, 1897:110. See above.
[*Lasiurus* (*Lasiurus*) *borealis*] *teliotis* Trouessart, 1904:87. See above.
Nycteris borealis teliotis Miller 1912:64. See above.
Lasiurus blossevillii frantzii Baker et al. 1988:9.
Lasiurus frantzii [*teliotis*] Baird et al. 2015:1266. First use of current name combination. See above.

Of the two recognized subspecies of the western red bat (Shump and Shump 1982b; Baird et. al. 2015), one occurs in Los Angeles County, *Lasiurus frantzii teliotis*. The western red bat is a California Species of Special Concern (CDFW 2021b). The most recent revision of the genus (Baird et al. 2015) placed the western red bat in the species *L. frantzii*. This species is considered to occupy most of western North America; *L. blossevillii* is now considered to only occupy South America, and *L. borealis* is now considered to occupy eastern North America. This species was reported in McLaughlin (1959) as *Lasiurus borealis teliotis*.

There are several records for this species in Los Angeles County, including records from Pasadena; Glendora; and North Hollywood; three from downtown Los Angeles; and single records from Exposition Park; San Antonio Canyon; Alhambra; Glendora; Hollywood; and the southern San Gabriel Mountains. Remington and Cooper (2014) reported this species in Griffith Park based on acoustic surveys. Brown and Berry (2005) acoustically recorded the western red bat in the SMMNRA and captured a reproductive female, and an adult male was found beneath an ornamental tree in downtown Hollywood in 2020 (J. Carpenter per. comm. 2022). This species has been acoustically recorded from several locations in the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) reported finding one specimen only but noted that citrus growers he interviewed said they occasionally saw this species hanging in citrus trees. The CNDDB tracks this species under its former name *L. blossevillii* and provides records for this species from the Santa Monica Mountains in the vicinity of Paramount Ranch from acoustic surveys. The western red bat is found in grasslands, shrublands, open woodlands, and mixed conifer woodlands. It is a tree-roosting bat, and its roosts are located in the foliage of trees and shrubs in woodland and forests as well as wooded urban and suburban areas (Shump and Shump 1982b). This species nomenclature has been subject to recent scientific debate (Novae et al. 2018; but see Baird et al. 2017; 2021).

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Myotis californicus: California myotis

Vespertilio californicus (Audubon and Bachman, 1842:285). Type locality is "California". Restricted to Monterey by Miller and Allen (1928:153).
Myotis californicus: Miller, 1897:69. First use of current name combination.
M. c. californicus Miller, 1912:56. First use of current name combination. See above.

Of four recognized subspecies, one occurs in Los Angeles County (Hall 1981; Simpson 1993; Burgin et al. 2020b): *Myotis californicus californicus*. There are several records for *M. californicus* from Los Angeles County. These are from Calabasas; southern San Gabriel Mountains; San Antonio Canyon; Pasadena; Covina; Santa Catalina Island; and San Clemente Island. Brown and Rainey (2018) report maternity colonies on Santa Catalina Island confirmed by direct observation and capture by mist net. Brown and Berry (2005) acoustically recorded and netted this species in the SMMNRA. Remington and Cooper (2014) reported this species in Griffith Park based on acoustic surveys. This species has been acoustically recorded from throughout the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) found California myotis in oak woodland below 1,520 m on the Pacific slope of the San Gabriel Mountains and in pinyon-juniper woodlands and the juniper belt on the desert slopes. The California myotis is found in a wide variety of habitats including desert scrub, sage scrub, chaparral, woodlands, and mixed and coniferous forests. It also occurs in urban and rural environments. It roosts in crevices, buildings, under bridges, in culverts, under loose bark on trees (such as ponderosa pine), caves, and mines (Simpson 1993).

Myotis ciliolabrum: Western small-footed myotis

Vespertilio ciliolabrum (Merriam, 1886:2). Type locality is "near Banner, Trego County, Kansas."
Vespertilio melanorhinus (Merriam, 1890a:46). Type locality is "San Francisco Mountain, Arizona." Narrowed to Little Spring, 8,250 feet, north base of San Francisco Mountain, Coconino County by Grinnell (1933). Name combination.
Myotis subulatus Miller and Allen, 1928:164. Type locality is "On the Arkansas River near the present town of La Junta, Otero County, southeastern Colorado."
Myotis ciliolabrum: van Zyll de Jong, 1984:2525. First use of current name combination.
Myotis subulatus melanorhinus Miller and Allen, 1928:169. See above.
M. c. melanorhinus van Zyll de Jong, 1984:2526. First use of current name combination. See above.

Of two subspecies, one occurs in Los Angeles County (Hall 1981; Holloway and Barclay 2001): *Myotis ciliolabrum melanorhinus*. There are a few records of *M. ciliolabrum* from San Antonio Canyon near the border with San Bernardino County, just north of Pinyon Hills in the Mojave Desert, Azusa, and one from Castaic. This species has been acoustically recorded from throughout the Angeles National Forest (A. Berkely pers. comm. 2021). Brown and Berry (2005) acoustically recorded and netted this species in the SMMNRA. It has been acoustically recorded from Castaic Lake (S. Norton pers. comm. 2022). The CNDDB (CDFW 2021a) provides two additional locations resulting from acoustic surveys, one at Mescal Creek in the desert facing foothills of the San Gabriel Mountains near the border with San Bernardino County and a second CNDDB location in Malibu State

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Park in the Santa Monica Mountains at Century Lake. This species may also occur on Santa Catalina Island (Brown pers. comm. 2022) based on a few acoustic detections. The western small-footed myotis is found in relatively arid wooded and brushy uplands near water, semiarid habitats, riparian areas near open grasslands, and pinyon-juniper and coniferous forests. It roosts in caves, buildings, mines, crevices, and sometimes under bridges and under loose tree bark. It has been documented roosting in abandoned swallow nests (Holloway and Barclay 2001). This species was reported in McLaughlin (1959) as *Myotis subulatus melanorhinus*.

Taxonomic note: Simmons (2005) and Burgin et al. (2020b) recognize *Myotis melanorhinus* as a distinct species, thus, creating two monotypic species: *M. ciliolabrum* in the midwest of the United States and *M. melanorhinus* on the west coast. However, a genetic analysis by Ammerman et al. (2016) indicates that *melanorhinus* is a subspecies of *M. ciliolabrum*, which is followed in this checklist.

The taxonomic history of this species is complex. Glass and Baker (1968) reviewed the history and issues with the specific name *subulatus* up to that time. *Myotis subulatus* was first applied to a bat in a footnote in James' (1823) account of the Long's expedition from Pittsburgh to the Rocky Mountains. A type specimen was not named, but in another footnote, it was mentioned that material was sent to a museum in Philadelphia (Peale's Museum). That museum subsequently suffered a fire, and the material was lost, leaving the name without a type specimen. Glass and Baker (1968) argued that the name *subulatus* actually applied to *M. yumanensis* based on the original description provided in James (1823) and thus *subulatus* should be suppressed (Glass and Baker 1965), but later they withdrew the petition. Based on their analysis of the history of the taxon they placed the two subspecies of *subulatus* into *Myotis leibii*. Hall (1981) did not follow Glass and Baker (1968), and resurrected *Myotis subulatus* and placed *leibii* in *subulatus*. van Zyll de Jong (1984) demonstrated that *M. ciliolabrum* is as distinct from *M. leibii* as either is from *M. californicus*, the other member of the *leibii* group. This resulted in the recognition of *M. ciliolabrum* as a valid species with two subspecies, as recognized in this check list.

Myotis evotis: Long-eared myotis

Vespertilio evotis (H. Allen, 1864:48). Type locality, by subsequent restriction, Monterey, Monterey Co., California (Dalquest, 1943).
Myotis evotis: Miller, 1897:77. First use of current name combination.
M. e. pacificus Dalquest, 1943:2. Type locality is "31/2 mi. E and 5 mi. N. Yacolt, 500 ft., Clark County, Washington."

Of six subspecies, one occurs in Los Angeles County (Hall 1981; Manning and Jones, Jr. 1989; Burgin et al. 2020b): *Myotis evotis evotis*. There are several records of *M. evotis* from Los Angeles County; one from the Mojave Desert near the community of Pear Blossom and Antelope Center; several records from San Antonio Canyon in the San Gabriel Mountains; along the San Gabriel River corridor; and two from the foothills in Pasadena and Sierra Madre; and one record from Santa Catalina Island (von Bloeker, 1967). An adult female was found at a building in Simi Valley in spring 2021 (J. Carpenter, pers. comm. 2022). This species has been acoustically recorded from locations throughout the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) reported this species as occurring on the Pacific slope of the San Gabriel Mountains up to 2,400 m and up to 1,800 m on the desert slopes in forested habitats. The CNDDB (CDFW 2021a) tracks this

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species; it lists a location near Valyermo, which is very near the Pear Blossom record. This record is based on six females captured by mist net and released. The long-eared myotis is found in shrublands, woodlands, and mixed coniferous forests. It roosts in tree cavities or large snags. It will also use buildings, cracks in the ground, caves, mines, and spaces under loose bark on living and dead trees (Manning and Jones, Jr. 1989).

Myotis lucifugus: Little brown myotis

V[*espertilio*]. *lucifugus* (LeConte, in McMurtrie,1831:431). Type locality Georgia, probably the LeConte Plantation, near Riceboro, Liberty County.
Myotis (*Leuconoe*) *carissima* Thomas, 1904:383. Type locality Lake Hotel, Yellowstone National Park, Wyoming. Name combination.
M. l. carissima Cary, 1917:43. First use of current name combination. See above.

This species was not previously reported in McLaughlin (1959). Currently, the literature indicates that the little brown bat does not occur in Los Angeles County, or along coastal southern California (Fenton and Barclay 1980; Hall 1981). However, unpublished acoustic surveys undertaken by the Angeles National Forest indicate that the *M. lucifugus* may occur in Los Angeles County (A. Berkely pers. comm. 2021). Although difficult to differentiate morphologically, the acoustic signatures of *M. lucifugus* and *M. yumanensis* are similar but can be distinguished (Weller et al. 2007; Rodhouse et al. 2008; Luszcz et al. 2016). For example, Herd and Fenton (1983) found significant differences in the search phase echolocation calls of *M. lucifugus* and *M. yumanensis*. The literature suggests that the minimum frequency calls can be used to differentiate *M. lucifugus* and *M. yumanensis* (Luszcz et al. 2016 and references cited therein). In addition, differences in characteristic frequency, the end point of the flattest (in terms of frequency) portion of an echolocation call (Corben and O'Farrell 1999), have also been used to distinguish between the two species (Weller et al. 2007). In addition, it is known that the acoustic signals of M. lucifugus and M. volans are very similar and may be confused with one another. The bat acoustic recordings made in the Angeles National Forest were identified by recognized experts on bat acoustics and who are familiar with bat species in southern California and the greater southwestern United States.

Although the literature suggests that *M. lucifugus* does not occur in coastal southern California, the identifications from the recordings from the Angeles National Forest presents an open question on the occurrence of *M. lucifugus* in Los Angeles County; therefore, I am including this species in this checklist provisionally. However, additional targeted research is needed that includes acoustic surveys combined with mist netting and genetic analysis to determine the presence of this species in Los Angeles County. If determined to be present, of five subspecies, only one would occur in Los Angeles County (Burgin 2020b): *Myotis lucifugus carissima*.

Taxonomic note: Morales and Carstens (2018) have provided evidence that all subspecies of *M. lucifugus* should be considered separate species. If accepted, this taxonomy would elevate *M. l. carissima* to species status as *M. carissima*.

Myotis thysanodes: Fringed myotis

Myotis thysanodes Miller, 1897:80. Type locality is "Old Fort Tejon, California". Grinnell (1933) added 3,200 feet elevation, Kern Co. to the type locality description.

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M. t. thysanodes Miller and Allen 1928:126. First use of current name combination. See above.

Of four subspecies, one occurs in Los Angeles County (Hall 1981; O'Farrell and Studier1980; Burgin et al. 2020b): *Myotis thysanodes thysanodes*. The fringed myotis is a California Species of Special Concern. There are few records of this species from Los Angeles County: one from Arcadia; near Santa Anita Park; one from the vicinity of Lake Los Angeles; and one from San Clemente Island. This species has been acoustically recorded from several locations in the Angeles National Forest (A. Berkely pers. comm. 2021). The CNDDB (CDFW 2021a) tracks this species and provides an additional location at Waterman Mountain in the San Gabriel Mountains. The fringed myotis is found in desert scrub and pinyon-juniper, hardwood, and hardwood-conifer forests. It roosts in caves, mines, tunnels, crevices, and old buildings (O'Farrell and Studier 1980).

Myotis velifer: Cave myotis

Vespertilio velifer (J.A. Allen, 1890:177). Type locality is "Sta. Cruz Valle, Guadalajara, Jalisco".
Myotis velifer: Miller, 1897:56. First use of current name combination.
M. v. velifer Grinnell, 1933:87. First use of current name combination (see above).

Of the three subspecies, one occurs in Los Angeles County, *Myotis velifer velifer* (Fitch et al. 1981; Hall 1981; Burgin et al. 2020b). *Myotis velifer* is not a well-known species in coastal southern California. Current literature has its distribution in California as along the Colorado River. However, a report by Constantine (1998) listed three localities in Los Angeles County: Florence, Lancaster, and Valencia. All three bats were collected from residences. These localities represent a very large range extension for this species, and they should be considered as vagrants until more specimens are obtained. The cave myotis is found in desert scrub and desert riparian habitats. It roosts in caves, mines, crevices, man-made buildings, and under bridges (Fitch et al. 1981). This species was not previously reported in McLaughlin (1959).

Myotis volans: Long-legged myotis

V[*espertilio*] *volans* (H. Allen, 1866:282). Type locality is "Cape St. Lucas, Lower Cal."
Myotis volans: Goldman, 1914:102. First use of current name combination.
M. longicrus interior Miller, 1914:211. Type locality is "five miles south of Twining, Taos County, New Mexico (altitude 11,300 ft.)".
M. v. interior Miller and Allen, 1928:142. First use of current name combination. See above.

Of four subspecies, one occurs in Los Angeles County (Hall 1981; Warner and Czaplewski 1984; Burgin et al. 2020b): *Myotis volans interior*. There are several records for *M. volans* in Los Angeles County: one from the Santa Monica Mountains near the border with Ventura County; downtown Los Angeles; Pasadena; Arcadia in the foothills of the San Gabriel Mountains; two from the headwaters of the Arroyo Seco in the San Gabriel Mountains; one from the desert facing foothills of the San Gabriel Mountains; San Antonio Canyon and one from the Mojave Desert near the border with San Bernardino County

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not far from Pinyon Hills. This species has been acoustically recorded from several locations in the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) did not consider this species to be plentiful, although he did find it on the Pacific and desert slopes of the San Gabriel Mountains up to the pine forest up to 2,400 m. The CNDDB (CDFW 2021a) tracks this species and provides two additional locations: one near Valyermo and one from Waterman Mountain. Both records are based on captured and released individuals. The long-legged myotis is found in woodland and forest habitats but can also be found foraging in chaparral and coastal scrub. It roosts in hollow trees, under tree bark, in rock crevices, in fissures in stream banks, on buildings, and in caves and mines (Warner and Czaplewski 1984).

Myotis yumanensis: Yuma myotis

Vespertilio yumanensis (H. Allen, 1864:58). Type locality is "Fort Yuma," Imperial County, California. Restricted to "Old Fort Yuma" by Miller (1897:66) and modified to Old Fort Yuma, Imperial County, California, on right bank of Colorado River, opposite present town of Yuma, Arizona" by Miller (1924:69).
Myotis yumanensis: Miller, 1897:66. First use of current name combination.
M. y. yumanensis Miller, 1912:56. First use of current name combination. See above.
M. y. sociabilis H. Grinnell 1914:318. Type locality is "Old Fort Tejon. 3200 feet altitude, Kern County, California".

Of six subspecies, one occurs in Los Angeles County (McLaughlin 1959; Hall 1981; Braun et al. 2015; Burgin et al. 2020b): *Myotis yumanensis sociabilis*. A second subspecies, *Myotis yumanensis yumanensis*, also may occur (see taxonomic note below). *M. yumanensis* needs revision to determine the subspecies number and spatial relationships in the state. *M. y. sociabilis* occupies the majority of the county from the coast east to the mountains and the desert facing foothills of the San Gabriel Mountains. *M. y. yumanensis* most likely occurs in the Mojave Desert portion of the county as shown in H. Grinnell (1918, Fig. J: page 275). There are many records of this species from Los Angeles County: Lebec, on the border with Kern County; the Santa Monica Mountains; Sylmar; Castaic; Tujunga; Azusa, in the foothills of the San Gabriel Mountains; one from Lancaster; and three from the Los Angeles Basin. There are also records from Santa Catalina Island including maternity colonies based on captures (Brown and Rainey 2018). Yuma myotis has been acoustically recorded from throughout the Angeles National Forest (A. Berkely pers. comm. 2021). This species is tracked by the CNDDB (CDFW 2021a), which provides some additional locations by capture and release: one near Little Rock Dam in the vicinity of Little Rock and another in Malibu State Park at Century Lake. Remington and Cooper (2014) found this species in Griffith Park based on acoustic surveys. The Yuma myotis is found in a variety of habitats, including deserts, desert riparian, open woodlands and forests, juniper woodlands, and riparian habitats. It is always associated with water and is relatively well adapted to (and commonly detected in) urban environments. Its roosts are located in caves, rock crevices, attics, buildings, mines, and underneath bridges and other similar structures. It also uses abandoned swallow nests (Braun et al. 2015).

Taxonomic note: During the preparation of this manuscript, I reviewed the distribution maps provided by Hall (1981) and Braun et al. (2015) and compared the subspecies shown to occur in Los Angeles County with existing literature (H. Grinnell 1914; 1918; Grinnell 1933; Miller and Kellogg 1955; Vaughan 1954; McLaughlin 1959). I found a

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discrepancy in the mapped ranges in subspecies for Los Angeles County. McLaughlin (1959) and Vaughan (1954) state the subspecies in Los Angeles County is *sociabilis,* whereas the distribution maps in Hall (1981) and Braun et al. (2015) showed *saturatus* and possibly *yumanensis*. The distributions of subspecies in the map provided in Hall (1981) do not match the marginal records provided for the subspecies *saturatus*, *yumanensis*, and *sociabilis*.

Based on a review of the literature, described below, *M. y. sociabilis* is the subspecies of *M. yumanensis* that occurs in Los Angeles County and coastal southern California. *M. y. yumanensis* most likely also occurs in the Mojave Desert of Los Angeles County.

Myotis yumanensis sociabilis - The type locality for *sociabilis* is Fort Tejon (H. Grinnell 1914), which is not in the range of Hall's (1981) map. Hall (1981) lists the following marginal records in California for *sociabilis*: Tahoe City, Fresno, Weldon, San Bernardino Mountains, and Lake Hodges near Escondido. In her original description of *sociabilis*, H. Grinnell (1914) assigned specimens from the following localities to *sociabilis*: "San Bernardino County - Bluff Lake, 7500 feet altitude, Bear Lake, 6700 feet altitude, South Fork Santa Ana River, 8500 feet altitude". She was not able to provide a full description of its range but provided the following: "It appears to occupy an intermediate geographic position between that of *M. y. yumanensis* and *M. y. saturatus*, namely the semi-arid Transition and Sonoran zones in California west and north of the southeastern deserts." Grinnell (1933) provides the following range for *sociabilis*: "Southern California west of the desert divides north through middle and northern California east of humid coast belt. Specimens examined from San Luis Rey, San Diego County, and Capistrano, Orange County, north to Beswick, Siskiyou County, and Alturas Lake, Modoc County; east toward south to San Bernardino Mountains and to Fresno; west toward north Chalk Peak, Monterey County, and to Winslow Glenn County." This description matches the range map provided by H. Grinnell (1918, Fig. J: page 275).

Myotis yumanensis saturatus - Hall's (1981) marginal records for *saturatus* in California include Baird, Oroville, Lake Alta, Yosemite Valley, San Simeon, thence northward along the coast and coastal islands to the point of beginning. Grinnell (1933) describes the range of *saturatus* as follows: "Northwestern humid coast belt, from Oregon line close to seacoast south as far as near Piedras Blancas, San Luis Obispo County; occurs interiorly at north as far as Baird, Shasta County ...". Therefore, it seems that *saturatus* ranges along the coast from San Luis Obispo County northward in California.

Myotis yumanensis yumanensis - Hall's (1981) marginal records for *yumanensis* in California include Mt. Whitney and jct. U.S. HWY 395 with McGee Creek, near Crowley Lake. Hall's (1981) range map shows *yumanensis* occupying the Mojave Desert south of Mt. Whitney, the eastern side of the Sierra Nevada, eastern side of the Coast ranges south to Mexico, but no marginal records are provided for this area. Grinnell (1933) provides the following range for *yumanensis*: "Parts of Colorado and Mojave Deserts; recorded south to Old Fort Yuma, on Colorado River, and northwest to vicinity of Lone Pine, Inyo County. Therefore, the range of *yumanensis* is restricted to the eastern side of the Coast ranges and the Sierra Nevada.

Parastrellus hesperus: Canyon bat

Scotophilus hesperus (H. Allen, 1864:43). Type locality is "Ft. Yuma, Cal."
Pipistrellus hesperus: Miller, 1897:88. Name combination.
Parastrellus hesperus: Hoofer et al. 2006. First use of current name combination.

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The canyon bat is monotypic (Hall 1981; Hoofer et al. 2006; Burgin et al. 2020b). There are over 70 museum records of this species from Los Angeles County. There are eight records from the Mojave Desert: seven from south of Lancaster to the border with San Bernardino County, and one south of Rosemond. There are five records in the San Gabriel Mountains, including three along the border with San Bernardino County and two in the mountains above San Fernando. Three records are along the Interstate 5 corridor, one each from Santa Clarita, Castaic, and south of Pyramid Lake. There are two records from the Santa Monica Mountains and four from the Los Angeles Basin. Remington and Cooper (2014) reported this species as present in Griffith Park based on acoustic surveys. This species has been acoustically recorded throughout the Angeles National Forest (A. Berkely pers. comm. 2021). Vaughan (1954) noted that the canyon bat is the most obvious and common bat on the lower Pacific slopes of the San Gabriel Mountains and is also found on the desert slopes up to 1,240 m. Brown and Berry (2005) noted this bat to be common acoustically in the SMMNRA and was captured on several occasions. This species has also been recorded along the Interstate-405 corridor in Van Nuys (J. Carpenter, pers. comm. 2022). The canyon bat is found in a variety of habitats but seems most closely associated with arid habitats with rocks and crevices (Grinnell 1914; Cook 1962). However, it can occur up into forested habitats (Sumner and Dixon 1953). Canyon bats roost in rock crevices, beneath rocks, in burrows (including kangaroo rat burrows), mines, bridges, culverts, palm trees, and buildings (von Bloeker 1932b; Stager 1943; Koford and Koford 1948; J. Carpenter pers. comm. 2022). The canyon bat is the earliest to take flight (O'Farrell and Bradley 1970) and can often be spotted by the naked eye flying at dusk. This species is not tracked by the CNDDB.

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Appendix I

Museum from which records were used to create this checklist: American Museum of Natural History; California Academy of Sciences; California State University Long Beach; Cheadle Center for Biodiversity and Ecological Restoration; Chicago Academy of Sciences; Field Museum of Natural History; Harvard University, Museum of Comparative Zoology; University of Illinois, Illinois Natural History Survey; Kansas University Biodiversity Institute and Natural History Museum; Natural History Museum of Los Angeles County; Louisiana State University, Museum of Natural Science; Occidental College, Moore Laboratory of Zoology; Michigan State University Museum; Queensland Museum; University of Alaska Museum; University of California Berkeley, The Museum of Vertebrate Zoology at Berkeley; University of New Mexico; Museum of Southwestern Biology; University of Puget Sound; Slater Museum of Natural History; Royal Ontario Museum; Santa Barbara Museum of Natural History; Texas Tech University, Museum of Natural Science Research Laboratory; University of Arizona Museum of Natural History; University of California Los Angeles Donald R. Dickey Bird and Mammal Collection; University of Connecticut Biodiversity Research Collections; University of Florida; University of Michigan, Museum of Zoology; University of Puget Sound, Slater Museum of Natural History; United State National Museum of Natural History; and Natural History Museum of Utah.

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Bycatch in the California halibut (*Paralichthys californicus*) Trawl Fishery

Kinsey E. Matthews,* Jacklyn L. Mohay, Jake W. Todd, and Richard M. Starr

Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039

Abstract.—Bycatch rates within the California halibut trawl fishery were calculated using landed catch data from 1997–2020 fishery logbooks and estimated using landed and discarded catches from 2002–2019 fishery observer data. Average bycatch rates were significantly different between the two datasets. The average bycatch ratio estimated from fishery logbooks was 0.36 ± 0.17 while the average bycatch ratio estimated from the observer data was 4.61 ± 1.29, based on the weight of bycatch to weight of California halibut catch. Additionally, the most frequently caught bycatch species were estimated for each dataset. Bycatch rates calculated from the observer data were closely aligned with fishery-independent surveys conducted by the California Department of Fish and Wildlife, signaling the importance of using fishery observers to obtain estimates of bycatch within the California halibut fishery. Spatial patterns of bycatch revealed that fishing effort was highest near Monterey, San Luis Obispo and Ventura. Our results suggest that data from logbooks alone are not sufficient to adequately estimate bycatch within the California halibut trawl fishery.

In 2018, the California Fish and Game Commission adopted a new master plan for California fisheries. The new master plan, titled "2018 Master Plan for Fisheries, A Guide for Implementation of the Marine Life Management Act" updated the original Master Plan, which was adopted in 2001 as required by the Marine Life Management Act (MLMA) of 1999.[1] The 2018 Master Plan advises a comprehensive approach to the prioritization of management actions by including an assessment of the risks that fishing poses to a given stock and to the ecosystem, the extent to which current management is addressing those risks, and associated socio-economic factors. One of the suggested objectives in the Master Plan is to characterize bycatch of nontarget organisms in California's fisheries and to develop appropriate management measures to minimize fishery impacts to habitats and species. It is important to note that these nontarget organisms can either be kept and sold at the market or thrown back into the sea either dead or alive, as "discards" based on regulatory or economic reasons. Once bycatch is adequately characterized, management agencies can take steps, if necessary, to modify fishery effort through modifications of seasons, catch limits, spatial use areas, or by implementation of bycatch reduction devices (BRD).

California halibut (*Paralichthys californicus*) is a locally important flatfish species that is caught in both commercial and recreational fisheries. The geographic range of Cali-

* Corresponding author: Kinsey.matthews@sjsu.edu

[1] California Department of Fish and Wildlife. 2018. 2018 Master Plan for Fisheries A Guide for Implementation of the Marine Life Management Act. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=159222&inline. Accessed: 25 July 2021

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fornia halibut is from Magdalena Bay, Baja California, to the Quillayute River in Washington, USA; however, they are most abundant in central and southern California (Kells et al. 2016). A report by Haugen (1990) contains a variety of early biological studies of California halibut. Several of the historical studies chronicled the early life history and growth rates of California halibut; however, the majority of these studies did not examine the differences in growth rates between central and southern California. MacNair et al. (2001) identified that females grew faster and larger than males (in both regions), and females in central California grew larger than those in southern California. They also found that roughly 69% of California halibut were males in southern California and 53% were males in central California (McNair et al. 2001). Southern California also had a higher proportion of older females than central California. However, MacNair et al. (2001) used a small mesh size for their trawls, which could bias the results towards smaller individuals. More recently, Barnes et al. (2015) and Barnes and Starr (2018) described spawning characteristics of California halibut in central California. Summer spawning, which lasts approximately 10 weeks, exhibits geographic differences, with earlier peaks occurring further south (Barnes et al. 2015; Barnes et al. 2018).

The commercial fishery was historically centered off southern California ports, but since 1980 it has shifted to central California, with over 64% of landings in the San Francisco area.[2] The three main gear types used to catch California halibut are otter trawl, set gill net, and hook-and-line gear.[2] Since 1992, trawl gear has accounted for 71% of California halibut landings, generating more than $1.7 million in annual revenue.[2] In 1971, the California Department of Fish and Wildlife (CDFW) established the California halibut trawl grounds (CHTG), and in 2004, trawling for California halibut within 3 nm (5.6 km) from shore was restricted to the CHTG. Currently, only those vessels issued a California halibut Bottom Trawl Vessel Permit (CHBTVP) are allowed to target California halibut with trawl gear in the CHTG. The current CHTG occur 1.8–5.6 km from shore between Point Arguello, located in Santa Barbara County, and Point Mugu, located in Ventura County, an area of 690 km^2 of state waters.[2] Vessels fishing within the CHTG can take up to 0.23 mt of incidental bycatch. Outside of the CHTG, California halibut trawl fishing occurs statewide in federal waters.

Obtaining accurate estimates of total bycatch, including discards, in the California halibut trawl fishery is important to fulfill the requirements of the California MLMA. Vessel skippers are required to submit logbooks, detailing information about the fishing day or fishing trip, to agencies such as CDFW or the Pacific States Marine Fisheries Commission (PSMFC) (California Code of Regulations, Title 14, Section 190). Members of the California halibut fishery keep records in federal trawl logbooks due to overlap between state and federal fisheries (e.g., a permitted federal groundfish trawl tow may occur on the same trip as a permitted state halibut trawl tow, and halibut trawlers encounter and retain federal groundfish species). Logbooks submitted by captains are first sent to the PSMFC staff and entered in the PSMFC eLogbook portal (https://elogbook.psmfc.org/# eLogbook (psmfc.org)) if any groundfish species were retained. Afterwards, logbooks are sent to CDFW and transferred into the CDFW Marine Logbook System (MLS). These logbooks include some information about a vessel's bycatch during a fishing trip.

[2] California Department of Fish and Wildlife. 2008. Review of California Halibut Trawl Fishery in the California Halibut Trawl Grounds. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=36120&inline. Accessed 26 July 2021.

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Another avenue of estimating bycatch is through the West Coast Groundfish Observer Program (WCGOP). The WCGOP was created in 2001 to obtain bycatch estimates from federally regulated fisheries as well as certain state managed fisheries, such as California halibut. The WCGOP independently contracts with fishery observers to identify species and record the landings, discards, and mortality rates of caught fishes (Northwest Fisheries Science Center 2010). Approximately 25% of the catches in the state-managed California halibut trawl fishery are observed each year. Bycatch within the California halibut trawl fisheries was estimated by fishery independent trawl surveys and from data obtained from the WCGOP. However, these studies were mainly conducted over the course of 1–2 years, so yearly trends in bycatch and bycatch ratios were not analyzed. Furthermore, no study has directly compared California halibut bycatch ratios between observer and logbook data.

We compared estimates of the amount and spatial distribution of bycatch within commercial California halibut trawl fisheries derived from logbooks with those from the federal observer program. State logbooks provided information about bycatch species that were retained and sold, along with their spatial distribution of catch. Observer data provided direct observations of bycatch within the California halibut trawl fishery, which included estimates of both landed species and discarded species. These two data sources were analyzed independently in order to evaluate the utility of landed catches to reflect the bycatch detailed by observers. Together, these two data sources provided a more comprehensive outlook on bycatch within the fishery, thereby yielding valuable information to address the MLMA's Ecosystem-Based Fishery Management goals of describing and characterizing bycatch in California's fisheries.

Materials and Methods

We selected and analyzed fishery logbooks that listed California halibut as the Target Strategy in the MLS database. The years 1980–1996 contained trawl data without a Target Strategy category and were thus excluded from analysis. We eliminated any logbooks that listed catches of California halibut caught deeper than 300 m and therefore out of the normal depth range (0–281 m) of California halibut, as they were likely to contain information that was not recorded or entered correctly. The resulting data set included MLS data from 1997–2020.

The WCGOP's Groundfish Expanded Multi-year Mortality (GEMM) data set provided fishery observer data from 2002–2009. The GEMM data set is a companion to the Groundfish Mortality Report and includes information about mortality, landings, and discard estimates of all observed species, excluding protected fish, marine mammals, sea birds, and sea turtles. These data are later combined with discard mortality rates and landings data to create the GEMM database. California halibut records within the GEMM database were split into multiple categories, such as Limited Entry (LE) California halibut, and Open Access (OA) California halibut fisheries. We combined LE and OA California halibut for the purposes of this study. There were no spatial data associated with the GEMM database, so we were not able to filter out deeper water trawls as we did for the MLS California halibut trawls; however, trawls that targeted California halibut would theoretically be fished out to the max depth of California halibut's range, as there are only limits on gear size and specific areas closed to fishing.[3]

[3] Code of Federal Regulations 50 Part 660 Subpart F. Available from: https://www.ecfr.gov/current/title-50/chapter-VI/part-660/subpart-F. Accessed 28 May 2022.

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We calculated yearly bycatch ratios of non-target landings to California halibut landings from the MLS data by dividing the summed estimated weight of all non-target landed species by the estimated weight of California halibut landed each year. We used a generalized additive model (GAM) to identify yearly trends in summed bycatch ratios. GAMs identify nonlinear relationships and patterns between response and explanatory variables, and thus can be useful when examining trends that might vary through time (Beck and Jackman 1998). Also, we used GAMs to determine nonlinear species-specific trends in bycatch.

To calculate the most abundant species caught as bycatch in the MLS data, we summed the individual weights of each species across all years, divided by the weight of total bycatch, and multiplied by 100. The logbook data included no descriptions of size, thus life stages were not differentiated in our analyses. All species that constituted more than 5% of the weight of total bycatch were identified as the top bycatch species and further examined to provide species-specific trends in bycatch. All other landed bycatch species that comprised less than 5% of the bycatch were grouped together in the "Other Species" category.

We used the GEMM data set to calculate yearly bycatch ratios of non-target landings and discards to California halibut landings and discards from observer data. The weights of all non-target landed and discarded species were divided by the weight of landed and discarded California halibut. We used a GAM to identify any nonlinear trends in bycatch ratios obtained from the GEMM data. The top bycatch species (species that constituted more than 5% of the total weight of bycatch) found in the GEMM dataset were calculated following the same protocols as we used with the MLS dataset.

After evaluating the individual datasets (MLS and GEMM), we combined them to ascertain differences in bycatch between the datasets. The MLS dataset was limited to the same time period as the GEMM dataset (2002–2019) in order to create a comparable time series. We used an ANCOVA with year as a covariate to determine these differences. We also standardized the data by the mean and the standard deviation in order to visually inspect differences in trends between the MLS and the GEMM datasets.

We evaluated spatial trends in fishing effort, locations, and bycatch ratios along the California coast. CDFW created a grid of 10-min of latitude by 10-min of longitude cells (each grid cell contained an area of ~377 km^2). These grid cells are known as commercial fishing blocks, and the grid extends from the shore to a distance of 180 km offshore (Miller et al. 2014). Additionally, there is a series of larger blocks on the offshore perimeter, and another set of blocks that extend from the shoreline to the Exclusive Economic Zone (EEZ). Commercial fishing vessels use these grids to report their catch and fishing locations. We used ArcMap 10.8.1 (Esri ArcGIS), to plot bycatch data on the CDFW fishing block grid, and created a series of maps to spatially illustrate fishing effort and highlight areas of high bycatch rates derived from MLS data in the California halibut trawl fishery. Only fishing blocks with information from three or more vessels were included in the spatial analyses due to confidentiality reasons. This excluded all data from northern California and many from depths beyond the 300 m isobath. We also separated the MLS data at known biogeographic boundaries (Cape Mendocino and Point Conception) to ascertain biogeographic differences in bycatch ratios. For this spatial analysis, we defined bycatch as species caught incidentally to the targeted species that are retained and sold, thus omitting species returned to the water dead or alive.

We created map layers depicting fishing effort (defined as total number of trawl tows) per grid cell, total catch, and bycatch ratios over time from 1990–2020. These data were superimposed over the CDFW fishing blocks to display fishing effort, total catch, and

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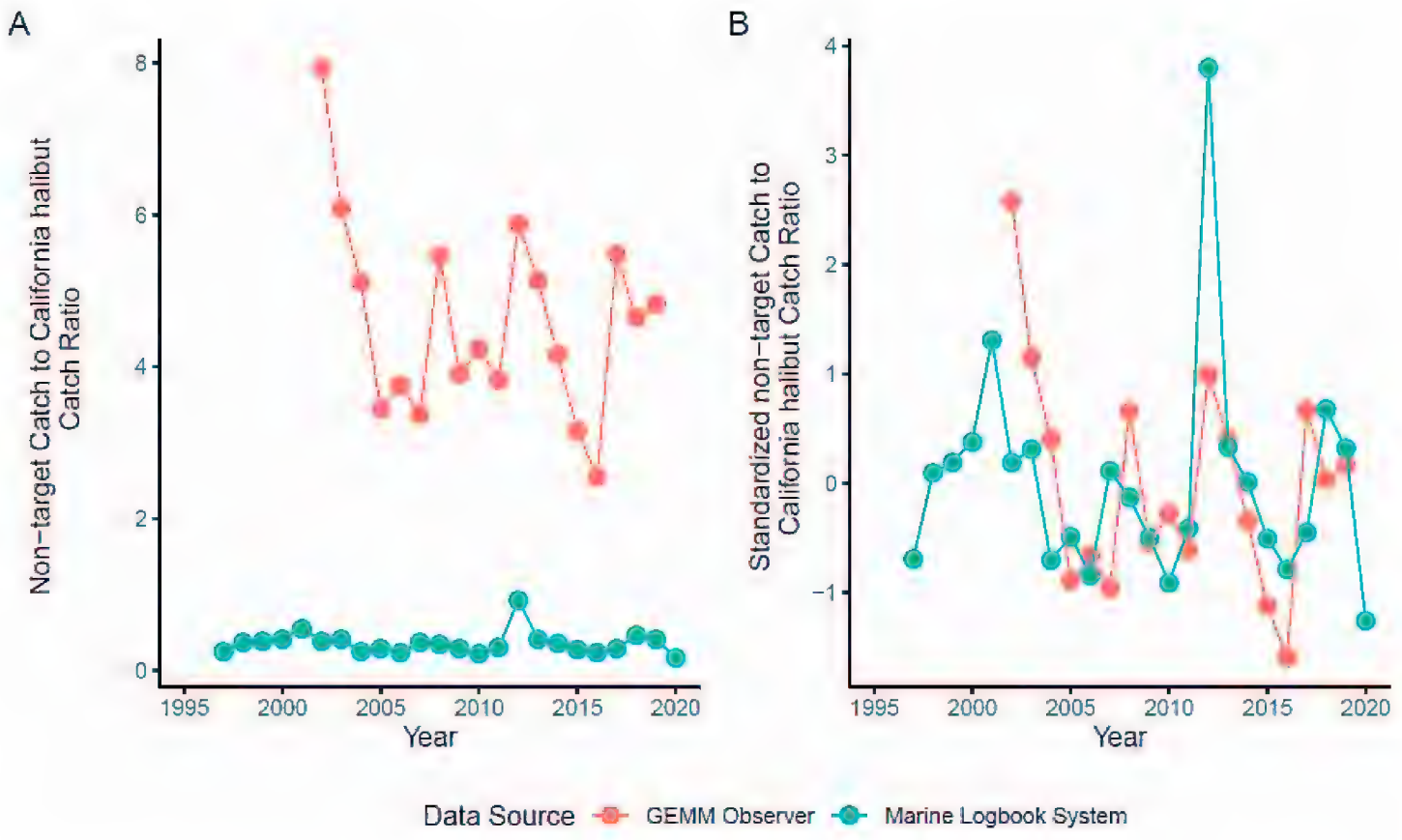

Fig. 1. Ratios of the non-target (not California halibut) catch to California halibut catch per year from the California halibut trawl fishery. The GEMM observer non-target catch included data on landings (kept individuals) and discards (discarded individuals) from 2002–2019, whereas the Marine Logbook System catch included only landings data from 1997–2020. Both datasets contain bycatch ratios calculated from the entire California coast. A) Non-standardized bycatch ratios B) Standardized bycatch ratios calculated from the mean and the standard deviation in order to view each dataset on the same scale.

bycatch ratios in each block. Frequency distributions of each metric were created, and then the natural jenks classification method in ArcMap was used to develop the symbol intervals as this method best illustrated changes in the distribution of the data.

Results

The annual bycatch ratios of all non-targeted species catch (landings) to California halibut catch (landings) from the 1997–2020 MLS data ranged from 0.17–0.56 and averaged 0.36 ± 0.165. In 2012, there was an anomalously high level of bycatch, with a total bycatch ratio of 0.95 (Fig. 1A). Further analyses indicated that this spike in bycatch was due to Petrale sole (*Eopsetta jordani*, 11 mt), unidentified sole, unidentified flatfishes (8 mt), sand sole (*Psettichthys melanostictus*, 8 mt), English sole (*Parophrys vetulus*, 7 mt), unidentified skates (6 mt), and starry flounder (*Platichthys stellatus*, 4 mt). A GAM used to analyze the entire 24-year data set proved to be nonsignificant, with an R^2 value of 0.04 and explained 0.34% of the deviance (Fig. 2A).

The top bycatch species that comprised over 5% of the total bycatch in the MLS data include: starry flounder (190 total mt), sand sole (176 total mt), unidentified skates skate (53 mt), unidentified flatfishes sole (42 total mt), and Southern rock role (*Lepidopsetta bilineata*, 37 total mt) (Table 1). Each of the top bycatch species also exhibited a spike in bycatch ratio in the year 2012 (Fig. 3A). Species included in the category "Other" are listed in Appendix I. The species-specific GAMs were significant for starry flounder and rock sole. The GAM for starry flounder yielded an R^2 value of 0.60 and explained 66.8% of the deviance. The bycatch ratio of starry flounder increased from 1997–2006 but decreased

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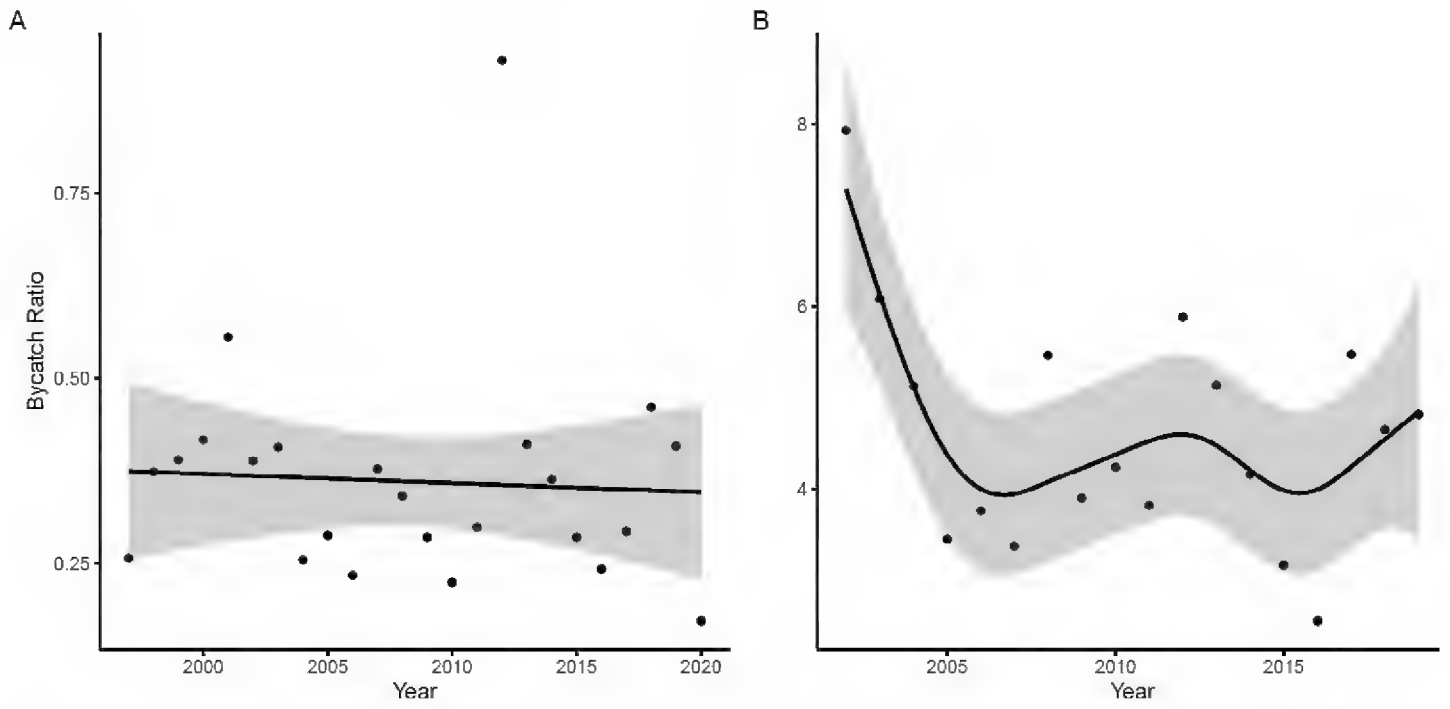

Fig. 2. Response curves showing the relationship between year and bycatch ratio of non-target (not California halibut) catch to California halibut catch calculated using a generalized additive model from A) The Marine Logbook System (1997–2020) and B) The GEMM Observer data (2002–2019). Shaded areas are the approximate 95% confidence intervals.

from 2007–2017. The GAM for rock sole had an R^2 value of 0.56 and explained 64.3% of the deviance. The bycatch ratio of rock sole increased from 1997–2004, and then steadily decreased from 2005–2019.

The average bycatch ratio of non-target species catches (discards and landings) to California halibut catch (discards and landings) from the 2002–2019 GEMM data was 4.61 ± 1.29. A GAM showed the relationship to be significant with an R^2 value of 0.5 and explained 62.7% of the variance (Fig. 2B). There was a nonlinear trend in bycatch ratios that varied throughout time. Specifically, bycatch ratios decreased until 2006 and have since gone through periods of increases and decreases. In 2002, the annual bycatch ratio was at its highest (~8) before it oscillated around a yearly bycatch ratio of about 4.5 (Fig. 1A).

The species comprising the top 5% of bycatch (all years combined) were Dungeness crab (*Metacarcinus magister*, 3,029 total mt), unidentified jellyfish (2,143 total mt), sablefish (*Anoplopoma fimbria*, 763 total mt), big skate (*Raja binoculata*, 626 total mt) and bat ray (*Myliobatis californica*, 562 total mt) (Table 2). "Other" species are listed in the Appendix II. Note that the occurrence of sablefish on this list reflects the fact that GEMM data are derived from federal observers, who are working on groundfish vessels fishing both in California waters and deeper federal waters. The species-specific GAMs were significant for jellyfish, sablefish, and the combined species in the "Other" category. The GAM for jellyfish provided an R^2 value of 0.61 and explained 71.5% of the deviance. The bycatch ratio of jellyfish decreased from 2002–2006 and periodically fluctuated after 2006. The species-specific trend line of unidentified jellyfishes closely matched the overall trend of bycatch in the GEMM dataset (Fig. 3B), which indicated that it could be driving the pattern seen in the GEMM data. We removed jellyfish from the analysis of the GEMM dataset and reran the GAM. After doing so, the overall GAM was not significant, meaning that jellyfish were in fact driving the significant pattern observed in the GEMM dataset. The GAM for sablefish provided an R^2 value of 0.61 and explained 70.4% of the deviance. The bycatch ratio of sablefish initially increased till 2007, decreased till 2012, and has increased

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Table 1. Total overall catches (mt) of California halibut and the top bycatch species. The right-hand column is the yearly bycatch ratio (i.e., total bycatch divided by California halibut catch), and the bottom row is the average bycatch ratio, across all years, for each species. Data from the Marine Logbook System (CDFW). Unid. = Unidentified.

Year	California halibut	Starry flounder	Sand sole	Unid. skate	Unid. sole	Northern rock sole	Other	Annual bycatch ratio
1997	78	5	8	1	1	0	4	0.26
1998	107	12	5	4	4	1	14	0.37
1999	81	8	4	5	1	0	14	0.39
2000	53	6	8	1	1	1	4	0.42
2001	62	4	11	8	1	0	10	0.56
2002	139	15	20	4	1	5	9	0.39
2003	80	10	10	2	0	3	8	0.41
2004	195	16	14	1	1	7	10	0.25
2005	192	21	12	1	1	7	13	0.29
2006	149	18	5	0	0	2	8	0.23
2007	60	7	3	1	2	2	7	0.38
2008	53	7	1	2	2	1	5	0.34
2009	74	10	2	1	0	1	7	0.29
2010	97	10	5	0	2	1	4	0.22
2011	81	4	8	1	6	0	4	0.3
2012	64	4	8	6	8	1	33	0.93
2013	72	3	10	1	7	1	8	0.41
2014	72	6	12	1	2	0	5	0.36
2015	87	5	7	1	0	1	11	0.28
2016	92	4	4	1	0	1	13	0.24
2017	90	3	4	6	0	0	13	0.29
2018	56	2	6	3	1	0	14	0.46
2019	50	4	2	0	0	0	14	0.41
2020	87	6	4	1	0	0	4	0.17
Avg. Ratio ± SD	-	0.09 ± 0.03	0.08 ± 0.05	0.03 ± 0.03	0.02 ± 0.03	0.01 ± 0.01	0.12 ± 0.1	0.36 ± 0.15

from 2012–2019. The GAM for "Other" species yielded an R^2 value of 0.65 and explained 73.3% of the deviance. The bycatch ratio of "Other" species decreased from 2002–2013, and increased from 2013–2019.

Additionally, the "Other" category exhibited spikes in 2002, 2003, 2017, 2018, and 2019. In 2002, the prominent "Other" species were unidentified skates, unidentified sanddab, dover sole, and sand sole. In 2003, the prominent "Other" species were dover sole, petrale sole, pacific sanddab, and English sole. In 2017, 2018, and 2019, the prominent "Other" species were Pacific halibut (*Hippoglossus stenoepsi*s), California skate (*Beringraja inornata*), sand sole, arrowtooth flounder (*Atheresthes stomias*), and longnose skate (*Beringraja rhina*).

Once the MLS dataset and the GEMM dataset were combined, we compared their overall similarities and differences in magnitude and trends. Bycatch ratios calculated from the GEMM data were higher than the bycatch ratios calculated from the MLS data (ANCOVA, $F_{(1,33)} = 195.6$, $P < 0.005$). We then standardized the two datasets and again compared their overall trends. Bycatch ratios from both the MLS dataset and the GEMM dataset fluctuated similarly over time (Fig. 1B).

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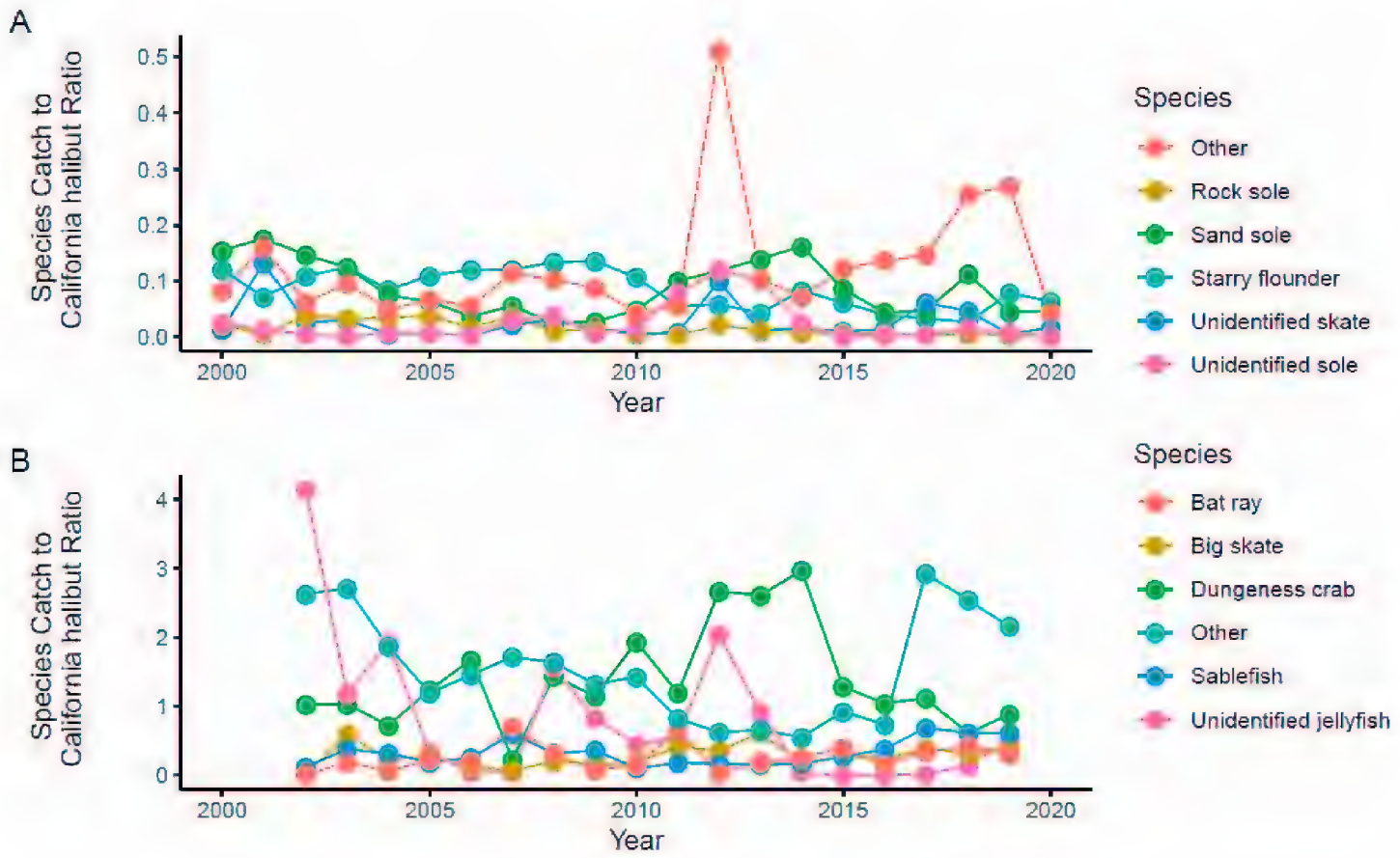

Fig. 3. Species-specific bycatch ratios of non-target (not California halibut) catch to California halibut catch in the California halibut trawl fishery. Top bycatch species were species that constituted at least 5% of the total bycatch within the California halibut trawl fishery from A) The Marine Logbook System (1997–2020) and B) The GEMM Observer (2002–2019). Both datasets contain bycatch ratios calculated from the entire California coast.

Spatially explicit catch and bycatch metrics for all years across the California coast are plotted in Figs. 4-5. Additional landings were reported coastwide, such as in northern California and farther from shore; however, those data were not plotted because CDFW policies prevent us from showing spatial locations in which fewer than three vessels reported catch in the associated fishing blocks. High bycatch ratios occurred near Eureka whereas moderate bycatch ratios occurred near Cape Mendocino. Additionally, low to moderate bycatch ratios occurred further offshore of central and southern California. Hotspots of higher catch rates that are displayed in the figures were found near Monterey, San Luis Obispo, and Ventura. Our spatial analysis showed that the highest bycatch ratios off of central California occurred in deeper waters than off of southern California (Fig. 4).

We saw no distinct relationships between fishing effort and bycatch ratios (Fig. 5). The highest fishing effort occurred in areas adjacent to Monterey, San Luis Obispo, and Ventura, which corresponds to locations containing high total catches as described above. The highest fishing effort was nearshore. Interestingly, there were also some blocks located in deeper water that exhibited higher levels of bycatch. We suspect that this is not real but is due to erroneous reporting of fishing locations in the MLS logbooks. Unplotted areas containing high fishing effort also occurred from Cape Mendocino to the Oregon border, and from Monterey Bay to Bodega Bay.

When we separated the bycatch ratios based off geographic location, the northern area exhibited higher bycatch ratios than the central and the southern areas (Fig. 6). However, there were only 4 years of data in the northern region, which spanned years from 1997–2000, whereas both the central and southern regions contained data from 1998–2015. The database we originally used contained 6 years of data in the northern region (1997–2002),

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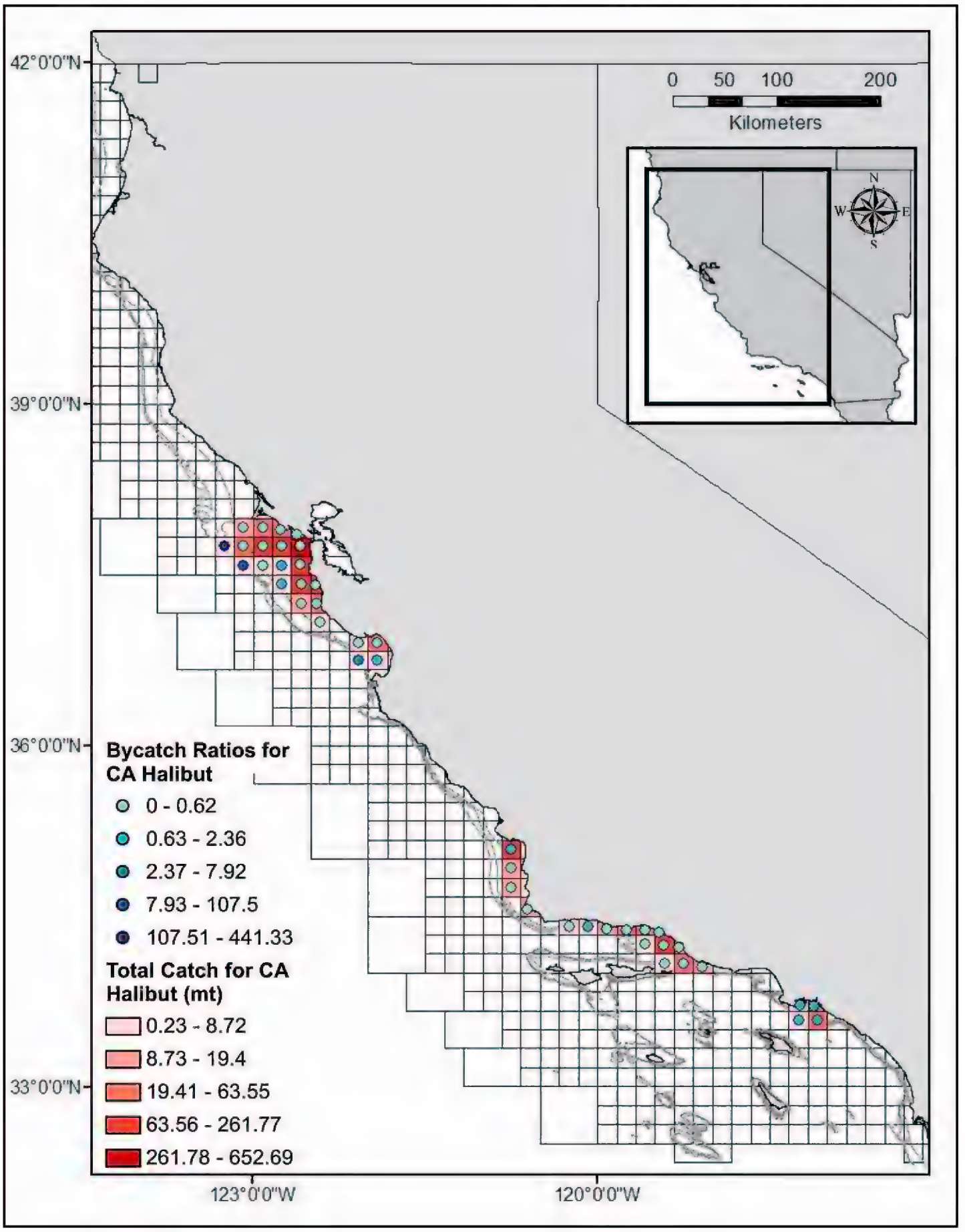

Fig. 4. Bycatch ratios of non-target (not California halibut) catch to California halibut catch layered over total catch (mt) for the California halibut trawl fishery using data from the Marine Logbook System (MLS) along the California coast. This plot represent data from 1997–2015. Class labels are defined by the Natural Jenks function in ArcMap 10.8 to best illustrate changes in symbol levels. Any fishing blocks with reported landings from less than 3 vessels were filtered out to meet CDFW regulations. Missing data were primarily concentrated along the north coast. Darker red blocks show higher catch totals compared to lighter red blocks. The darker blue symbols indicate higher bycatch ratios than lighter blue. CDFW commercial fishing blocks with no reported catch are in white. Light gray lines depict the 100–300 m isobaths.

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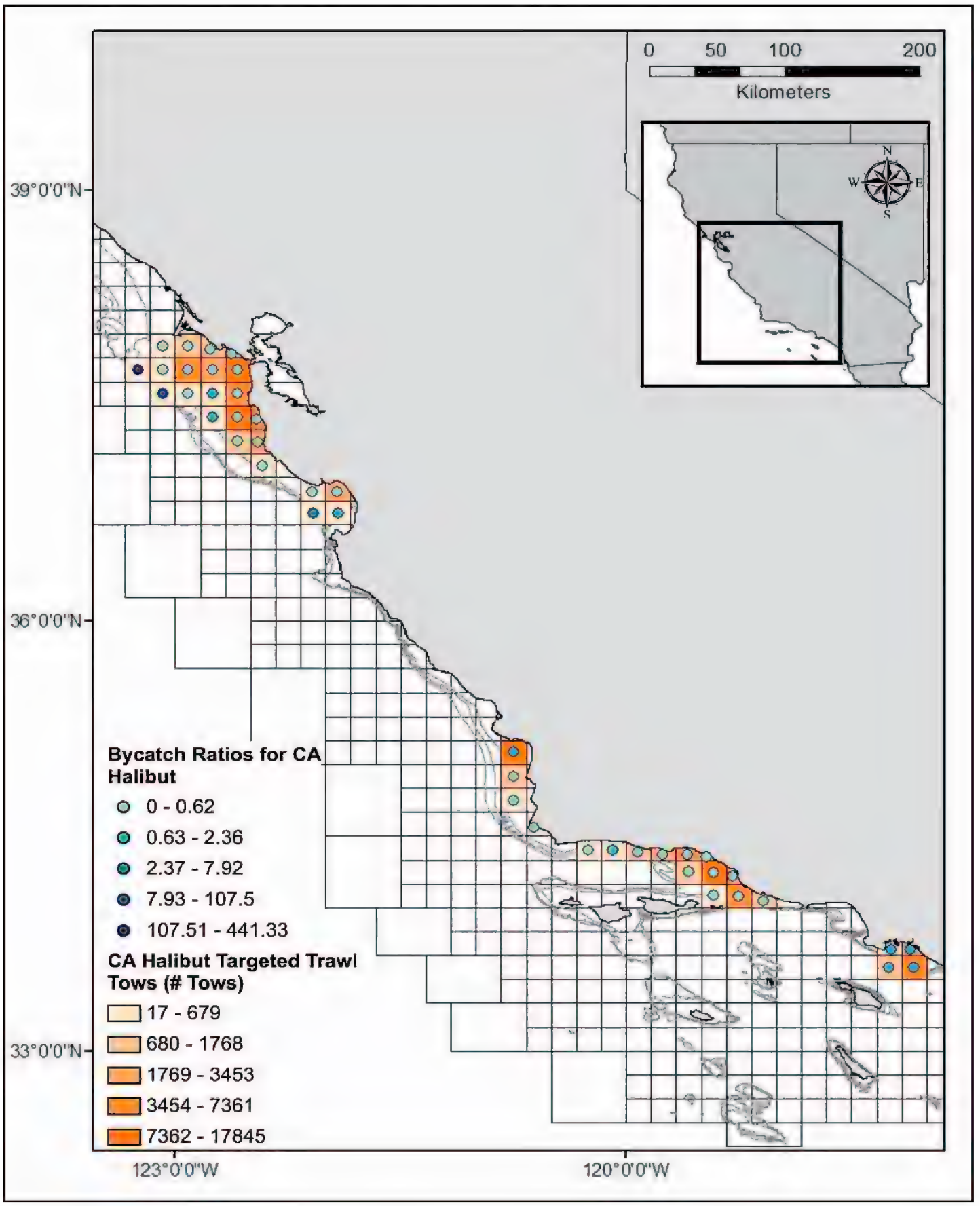

Fig. 5. Bycatch ratios of non-target (not California halibut) catch to California halibut catch plotted over the number of California halibut targeted tows in each fishing block using data from the Marine Logbook System (MLS) along the California coast. This plot represents data from 1997–2015. Class labels are defined by the Natural Jenks function in ArcMap 10.8 to best illustrate changes in symbol levels. Any fishing blocks with reported landings from less than 3 vessels were filtered out to meet CDFW regulations. These data were primarily concentrated along the north coast. Darker orange blocks show a higher number of trawl tows compared to lighter orange blocks. The darker blue symbols indicate higher bycatch ratios than lighter blue. CDFW commercial fishing blocks with no reported trawl tows are in white. Light gray lines depict the 100–300 m isobaths.

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Table 2. Total overall catches (mt) of California halibut and the top bycatch species. The right-hand column is the yearly bycatch ratio (i.e., total bycatch divided by California halibut catch), and the bottom row is the average bycatch ratio, across all years, for each species. Data from GEMM observer program (NOAA). Unid. = Unidentified.

Year	California halibut	Dungeness crab	Unid. jellyfish	Sablefish	Big skate	Bat ray	Other species	Annual bycatch ratio
2002	182	187	754	22	1	2	478	7.93
2003	153	158	181	57	91	29	416	6.08
2004	219	159	421	70	50	14	409	5.12
2005	264	327	87	50	73	59	315	3.45
2006	185	311	8	47	24	37	270	3.76
2007	83	19	4	50	6	59	143	3.37
2008	115	166	180	36	23	36	188	5.46
2009	136	156	113	49	22	11	181	3.90
2010	131	254	58	14	25	19	187	4.24
2011	98	117	55	17	40	64	80	3.82
2012	56	148	113	9	20	2	35	5.88
2013	70	182	64	11	43	13	46	5.13
2014	87	258	4	14	15	22	48	4.16
2015	103	132	0	28	29	41	96	3.16
2016	105	110	0	40	25	16	77	2.55
2017	115	129	2	80	44	39	337	5.47
2018	101	61	14	62	32	44	257	4.64
2019	174	155	85	107	63	54	376	4.82
Avg. Ratio ± SD	-	1.37 ± 0.74	0.82 ± 1.06	0.33 ± 0.19	0.28 ±0.16	0.26 ± 0.19	1.55 ± 0.78	4.62 ± 1.25

but the average bycatch ratio in 2001 was over 1,000, and the average bycatch ratio in 2002 was 44. These were assumed to be outliers that resulted from human or computer error and were therefore removed. This resulted in an average bycatch ratio of 5.16 from the MLS dataset in the north region. The average bycatch ratio in the central region was 0.36, and the average bycatch ratio in the south region was 0.40.

Discussion and Conclusions

The results of our study highlight the differences between bycatch ratios obtained from analyses of logbook and observer-based estimates of bycatch. Within the California halibut fishery, the average bycatch ratio (weight of bycatch to weight of California halibut) calculated from the MLS logbook system, which only reports landed catch, was 0.36 ± 0.17, whereas the average bycatch ratio calculated from the federal on-board observer program, which reports both landed and discarded catch, was 4.61 ± 1.29. This is a more than ten-fold difference in bycatch ratios. The combination of bycatch from both discards and retained species were often much higher than the bycatch obtained from only retained species. Although the magnitudes of the bycatch ratios were different, each dataset seemed to follow a similar trend. Generally speaking, as one bycatch ratio increased or decreased, the other did as well. We believe that this correspondence is an indication that the fishing vessels carrying observers were fishing in the same general areas as the rest of the fleet. In the years that the fleet encountered high levels of bycatch (as indicated from vessel

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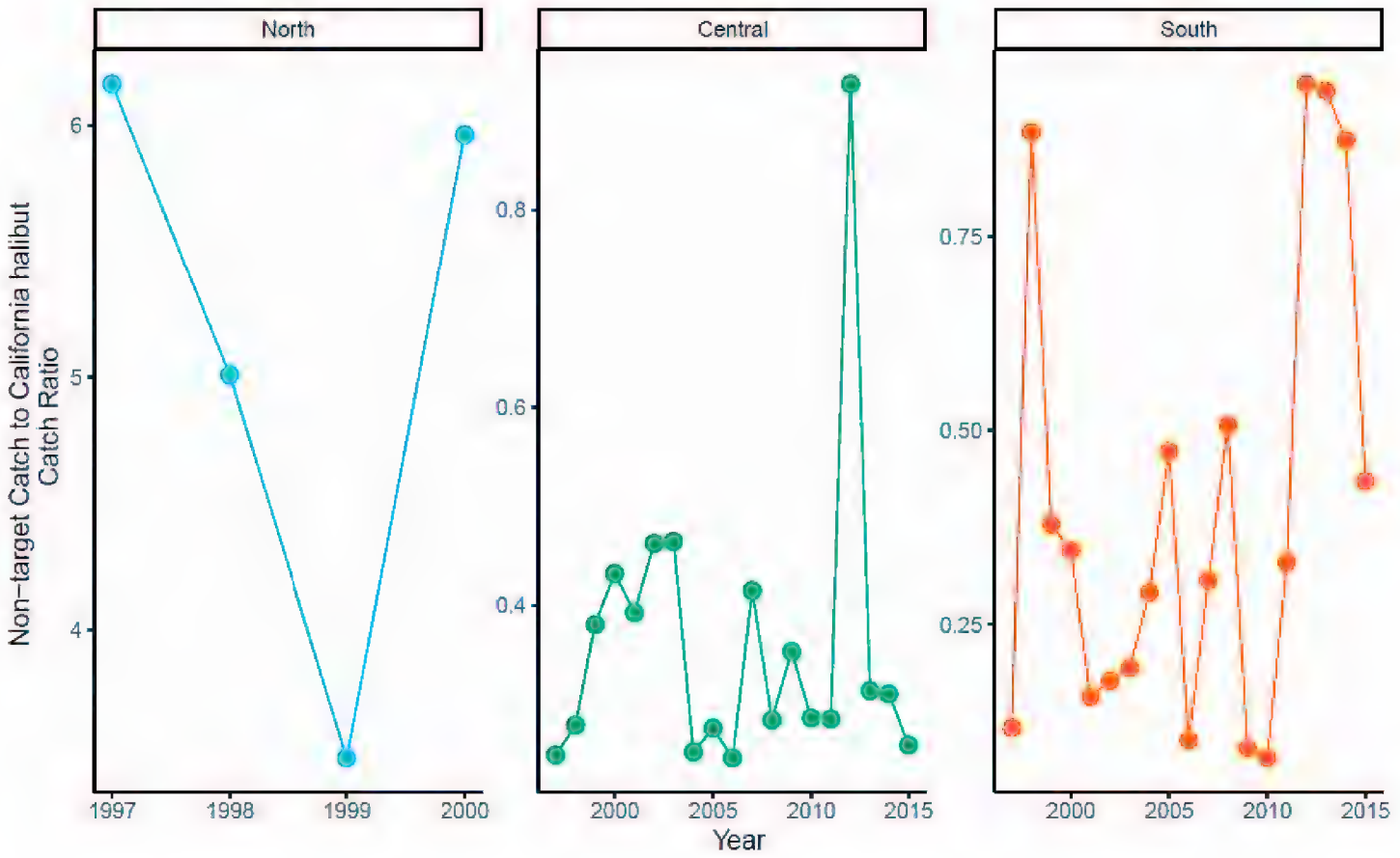

Fig. 6. Biogeographic and yearly differences of non-target (not California halibut) catch to California halibut catch in the California halibut trawl fishery using data from the Marine Logbook System (MLS). The north represents CDFW fishing blocks above Cape Mendocino, and the south represents CDFW fishing blocks below Point Conception. Central represents the area between Cape Mendocino and Point Conception. This plot represents northern data from 1997–2000, central data from 1997–2015, and southern data from 1997–2015.

logbooks), the GEMM observer data reflected that high bycatch. In years in which the fleet was fishing in "cleaner" areas, the GEMM observer also reflected low bycatch.

Clearly, the bycatch ratios calculated from the MLS are not representative of the true bycatch, as they are missing the primary component of bycatch, i.e., discarded bycatch. If a consistent proportion of fishing trips contained observers over a long time period (e.g., 25% per year), then total bycatch could be estimated from those data. However, Table 3 shows that there is a large variation in the proportion of fishing trips containing observers.[4] Thus, observer coverage is highly variable in both time and space, such that it is unlikely that a simple expansion of observed bycatch to total annual bycatch would be accurate for the entire state, let alone specific regions of the state.

It is also important to know that the trend in bycatch ratios from the MLS data was neither increasing nor decreasing, while the trend in bycatch ratios from the GEMM data was a significant nonlinear trend. When the bycatch of jellyfish was removed from the GEMM data, however, the bycatch data also indicated no significant trend with time. This indicates no bias between the two data sets and that observer data may be useful in identifying trends in bycatch within the California halibut trawl fishery, if observer coverage occurs within a statistically relevant sampling design.

[4] Somers, K.A., J.E. Jannot, K.E. Richerson, V.J. Tuttle, J.T. McVeigh (2021) Fisheries Observation Science Program Coverage Rates, 2002-20. NOAA data report NMFS-NWFSC. Available from: https://doi.org/10.25923/9rpa-9t92. Accessed 05 September 2021.

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Table 3. GEMM observer coverage rates for the California halibut trawl fishery, separated into the Limited Entry and the Open Access sectors. Original table obtained from NOAA Fisheries: https://doi.org/10.25923/9rpa-9t92

Sector year	Observed				Fleet total California halibut landings (mt)	Coverage rate % California halibut landings observed
	# of vessels	# of trips	# of tows	California halibut landings (mt)		
Limited Entry						
2002	7	19	52	3.6	108.5	3%
2003	12	73	207	19.1	105.7	18%
2004	8	46	171	31.5	136.5	23%
2005	10	74	235	30.5	188.9	16%
2006	9	78	224	14.3	119.5	12%
2007	5	40	81	5.4	18.6	29%
2008	6	40	118	9.6	36.4	26%
2009	3	12	29	2.9	47.2	6%
2010	Combined with OA below					
2011	3	63	157	11.9	11.9	100%
2012-13						
2014-18	After catch shares implementation, effort greatly decreased and has since ceased.					
Open Access						
2002					36.1	
2003	5	18	110	2.0	25.7	8%
2004	4	53	244	5.1	70.8	7%
2005	6	59	362	7.4	64.5	12%
2006					54.8	
2007	8	48	227	2.7	39.2	7%
2008	7	49	199	2.7	51.8	5%
2009	3	9	30	0.6	82.3	1%
2010	8	43	153	8.8	123.5	7%
2011	13	48	204	12.4	79.9	16%
2012	7	27	78	3.5	55.3	6%
2013	5	29	81	4.3	69.0	6%
2014	7	51	145	18.1	81.0	22%
2015	8	100	339	30.6	92.0	33%
2016	11	114	500	27.3	89.5	31%
2017	13	130	555	24.3	92.8	26%
2018	11	136	545	18.6	72.4	26%
2019	14	156	528	32.2	120.7	27%

The high bycatch ratios reported from the GEMM data is further corroborated by research trawl surveys conducted by CDFW. CDFW conducted fishery independent research trawls in 2008, 2013, 2018, and 2019. All species caught in these trawls were released. In 2008, Bell and Tanaka used standard commercial gear to conduct California halibut trawl surveys in the Santa Barbara region.[5] Trawl tows were approximately 1 hr in length in depths from 15–53 m. They caught approximately 1,430 organisms, comprising more than 50 species of invertebrates and fishes. The ratio of the number of individuals in the non-

[5] Bell, S. and T. Tanaka. 2008. Cruise Report, State Finfish Management Project Southern California Fishery-Independent Halibut Trawl Survey. California Department of Fish and Wildlife, Marine Region. 13 pp. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=33772. Accessed 15 June 2021.

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target bycatch to the number of legal and sublegal California halibut caught was 11:1. In 2013, CDFW conducted twenty 30-min trawl tows over the course of 4 days in the Monterey Bay region.[6] Survey depths ranged from 22–75 m. More than 30 species of fishes and invertebrates were captured, with a ratio of bycatch to legal California halibut catch of 4.31, by weight. Lastly, in 2018 and 2019, CDFW conducted trawl surveys in shallow water (2.5–6 m deep) off southern California, from Los Angeles to San Diego. A total of 45 different species was caught, with a bycatch ratio of non-target catch to legal California halibut catch of 8.91, by individual count.[7] The bycatch ratios calculated from the CDFW research trawl studies in 2008, 2013, and 2018–19 are more similar to the bycatch ratios calculated from the GEMM observer data than the MLS data. This is not surprising, as the MLS data set only reports kept species, whereas both the GEMM data set and the CDFW research trawls reported catches of all species. This highlights the need to obtain information about discarded species as well as retained catch if the goal is to evaluate impacts of trawl fishing on the ecosystem.

If bycatch rates are deemed to be unacceptably high, bycatch reduction devices (BRDs) could be one way to reduce bycatch within the California halibut trawl fishery. Lomeli and Wakefield (2016) investigated the use of BRDs in the U.S. West Coast nearshore flatfish trawl fishery. The authors utilized a flexible sorting grid BRD that was specifically designed for the exclusion of Pacific halibut, and a recapture net to quantify the percent escapement. The BRD reduced bycatch of Pacific halibut, shelf rockfishes, slope rockfishes, and sablefish by 90.3%, 80.3%, 64.0%, and 97.0% by weight, respectively (Lomeli and Wakefield 2016). Currently, vessels targeting California halibut are required to have a minimum codend mesh size of 19 cm (7.5") in to reduce bycatch within the CHTG; however, outside of the CHTG there are no state or federal requirements of BRDs within the California halibut fishery.[2] Utilization of BRDs such as the one employed by Lomeli and Wakefield (2016) could help to reduce bycatch.

This study informs a large policy issue related to understanding the bycatch in California trawl fisheries. Currently, a lack of fishery observers at sea in most state-managed fisheries creates considerable uncertainty about the type and volume of species caught and discarded at sea. This is problematic, as bycatch can cause population declines through direct morality, delayed mortality, or sublethal injuries that affect an individual's fitness or ability to reproduce (Prena et al. 1999; Lewison et al. 2004; Meyer et al. 2017). Affected populations can include marine mammals, elasmobranchs, seabirds, fishes, and invertebrates (Probert et al. 1998; Garcia et al. 2008; Heales et al. 2008; Tonks et al. 2008; Lewison et al. 2014). In addition, bycatch can cause deleterious effects on ecosystems and economies (Hall et al. 2000; Harrington et al. 2005; Kumar and Deepthi 2006). Until more spatially and temporally distributed surveys are obtained from video or visual observations of catches at sea, it will be difficult to evaluate the impacts of bycatch in most state fisheries The information that is available from at-sea observer programs, however, confirms

[6] Wick, T.L, T. Tanaka, C.P. Naresh, L. Enriquez. 2014. An assessment of the use of light-touch California halibut trawl gear within historic Monterey Bay trawl grounds: seafloor interactions, catch composition, and economic feasibility. Final Report, NOAA Fisheries and California Department of Fish and Wildlife. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=85387&inline. Accessed 25 June 2021.

[7] California Department of Fish and Wildlife. 2021. Unpublished survey data. Available from: https://wildlife.ca.gov/Conservation/Marine/Nearshore#56021327-california-halibut. Accessed 25 June 2021.

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that the discard of unwanted species at sea is higher than would be predicted from landed catches.

In addition to an increase in spatial and temporal observations of catches, more information about the survival rates of released species would be valuable. Post release survival rates can greatly vary among species. Some species, such as lingcod (*Ophiodon elongatus*) and sandbar sharks (*Carcharhinus plumbeus*) are resilient, and have survival rates of 100% and 97%, respectively, under low (<30 min) handling time (Parker et al. 2002; Whitney et al. 2012). For other species, studies suggest that discard mortality could be greater than capture or harvest mortality, such as for Murray cod (*Maccullochella peelii*), porbeagle (*Lamna nasus*) and blue sharks (*Prionace glauca*) (Douglas et al. 2010; Campana et al. 2016). Further research is needed to quantify species-specific survival rates, which would aid in our understanding of the effects of bycatch.

Results from the spatial analyses indicate that areas of moderate to high bycatch ratios are persistent throughout the entire coastline and at different depths, rather than at localized areas. This suggests the need for increased at-sea observer coverage within the state fishery to identify reasons for high bycatch ratios. If human observers are too expensive or it is too difficult to accommodate fishery observers on fishing trips, CDFW could consider the use of electronic monitoring systems. The use of electronic monitoring systems is increasing around the world as video systems become cheaper and automated identification systems are getting better (e.g., Gilman et al. 2020; van Helmond et al. 2020).

Published observer data, such as the GEMM database, would be more useful if it contained spatial data associated with the fishing effort. This would allow bycatch and catch totals to be plotted inside the CDFW fishing blocks, which might show different patterns than what are evident when plotting solely MLS data. Areas of high catch rates are focused around major fishing towns, but it is well known that distance to port strongly influences fishing effort, which is shown in our trawl effort map (Caddy and Carocci 1999; Stelzenmüller et al. 2008; Russo et al. 2016; James et al. 2018). Our trawl effort map also showed that there were a few blocks located offshore of San Francisco that exhibited low effort (smaller number of tows), but high bycatch ratios. These could be important areas for future spatial management.

We created qualitative time-series maps of the average bycatch ratios and the average total catch per fishing block from 1997–1999, 2000–2009, and 2010–2019 across the California coast. Bycatch ratios tended to be lower in the time period of 2010–2019 than 2000–2009. This could reflect area closures due to increased fishing pressure, fishery policy changes, or the reallocation of quotas (Porzio 2012). Time-series analyses could be used to illustrate a shift in fishing pressure throughout time; however more years of data are needed to identify significant trends. Our time series is relatively short (18 yrs of GEMM data) compared to other time-series analyses, which might make it too short to discern significant patterns or trends. For example, Chavez et al. (2003) used a 50-yr dataset to detect a regime shift from anchovies to sardines in response to several environmental covariates, many of which were large-scale oceanographic conditions. During the relatively short time period of our analyses, perturbations occurred that could have confounded the results of a time-series analysis. The strong 1997–98 El Niño event corresponded with the start of our MLS dataset. El Niño events, in which tropical, warm water spreads northward, can affect species distributions, abundances, and compositions (Ñiquen and Bouchon 2004). California and the northeast Pacific also experienced an extreme marine heatwave from 2014–16 (Di Lorenzo and Mantua 2016), which can drastically shift species habitats and distributions (Jacox et al. 2020). These two perturbations could have affected which, and

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how many, species were caught in California halibut trawl tows those years. With additional years of information, future, more traditional time-series analyses, might allow us to identify trends in bycatch related to environmental factors.

Additionally, when investigating biogeographic differences, bycatch ratios in the central and southern regions were similar. However, trawl effort and total landings were lower in southern California than central California, meaning that bycatch is relatively high in southern California compared to effort. This may be true in northern California as well. Further analyses could standardize bycatch ratios by effort to obtain a more accurate representation of biogeographic differences. Additionally, this study only provides information about bycatch in California halibut trawl fisheries. Gill nets are commonly used in southern California to catch California halibut and commercial hook-and-line fishing is popular in central California.[8] It would be useful to obtain comprehensive bycatch information from all types of California halibut fisheries, so bycatch ratios obtained from different gear types could be assessed when evaluating bycatch across the whole California halibut fishery. Overall, these results indicate a strong need for continued and/or expanded observations (human or electronic) of bycatch from California state-managed fisheries.

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Appendix I. All "Other" species caught in the California halibut fishery and their summed estimated weights from 2000–2020 according to the Marine Logbook System (MLS) dataset. Species showing 0.00 landings (mt) had a total catch of less than 0.01 mt.

Other species	Landings (mt)	Other species	Landings (mt)
Petrale sole	36.07	Bocaccio rockfish	0.28
Unidentified shark	29.22	China rockfish	0.25
English sole	24.23	Unidentified near-shore rockfish	0.20
White seabass	18.09	Thresher shark	0.11
Unidentified sea cucumber	17.59	Canary rockfish	0.08
Sanddab	17.47	Arrowtooth flounder	0.07
Unidentified trawled fish	14.73	Longspine thornyhead	0.07
Lingcod	11.20	California sheephead	0.06
California scorpionfish	8.60	Yellowtail rockfish	0.06
Chilipepper rockfish	6.62	Cabezon	0.06
Curlfin sole	6.41	Longnose skate	0.05
Group shelf rockfish	6.29	Darkblotched rockfish	0.05
Leopard shark	3.98	Vermilion rockfish	0.04
Soupfin shark	3.96	California skate	0.03
Mantis shrimp	3.45	Pacific sanddab	0.03
Cow sharks	3.21	Unidentified mackerel	0.03
Unidentified rockfish	3.18	Jumbo squid	0.02
White croaker	2.58	Flag rockfish	0.02
Sablefish	2.23	Kelp greenling	0.02
Big skate	2.07	Stripetail rockfish	0.02
Rex sole	1.37	Shortbelly rockfish	0.01
Ridgeback prawn	1.32	Shortspine thornyhead	0.01
Turbot	1.17	Rosy rockfish	0.01
Unidentified octopus	1.06	Mixed thornyheads	0.01
Bank rockfish	0.99	Pacific cod	0.01
Unidentified flounder	0.91	Group Slope Rockfish	0.01
Dover sole	0.80	Copper rockfish	0.00
Pacific whiting	0.71	Pacific Ocean perch rockfish	0.00
Unidentified bolina rockfish	0.54	Spot prawn	0.00
Dungeness crab	0.53	Pacific mackerel	0.00
Brown rockfish	0.43	Olive rockfish	0.00
Spiny dogfish shark	0.32	Black rockfish	0.00
Widow rockfish	0.28		

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Appendix II. All "Other" species caught in the California halibut fishery and their summed estimated weights from 2002–2019 according to the GEMM Observer dataset. Species showing 0.00 landings (mt) had a total catch of less than 0.01 mt.

Other species	Total discards & landings (mt)	Other species	Total discards & landings (mt)
Pacific halibut	484.6	Yellowmouth rockfish	0.26
California skate	291.85	Speckled sanddab	0.25
Unidentified skate	261.55	Mantis shrimp	0.23
Starry flounder	229.71	Unidentified crustacean	0.22
Petrale sole	217.36	Slender sole	0.22
Sand sole	209.96	Pacific herring	0.21
Pacific sanddab	193.38	Pacific Ocean perch	0.19
Dover sole	154.69	CA sea cucumber	0.17
Spiny dogfish shark	139.74	Unidentified urchin	0.17
Curlfin sole	123.01	Unidentified grenadier	0.15
English sole	118.01	Pacific mackerel	0.15
Brown smoothhound shark	104.29	Unidentified snailfish	0.14
Longnose skate	91.53	Unidentified eelpout	0.14
Pacific electric ray	81.68	Jack mackerel	0.13
Unidentified sea star	72.03	Filetail cat shark	0.12
Lingcod	71.49	Giant wrymouth	0.11
Rock sole	70.84	Unidentified smelt	0.10
Chilipepper rockfish	70.25	Kelp bass	0.09
Pacific angel shark	61.73	Unidentified mackerel	0.08
White croaker	54.64	Purple globe crab	0.08
Leopard shark	51.45	Spotted turbot	0.08
Unidentified sanddab	46.58	Unidentified bass	0.08
Arrowtooth flounder	45.88	Roughback sculpin	0.07
Unidentified invertebrate	40.2	Ocean whitefish	0.07
Bank rockfish	29.06	Pelagic thresher shark	0.07
Sheep crab	24.39	Common/giant Pacific octopus	0.07
Splitnose rockfish	24.11	Aleutian skate	0.06
Red rock crab	23.9	Unidentified tunicate	0.06
Striped bass	23.26	Unidentified poacher	0.06
White sea bass	21.01	Unidentified sturgeon	0.06
Shovelnose guitarfish	20.66	Butter sole	0.06
Graceful crab	20.49	Yellowtail jack	0.06
Rex sole	20.29	Spot prawn	0.06
Hornyhead turbot	20.25	Threadfin sculpin	0.06
Spotted ratfish	20.01	California tonguefish	0.05
Unidentified croaker	18.22	Black and yellow rockfish	0.05
Thornback	17.45	Shortbelly rockfish	0.05
Shortspine thornyhead	16.47	Greenblotched rockfish	0.05
Unidentified flatfish	15.02	Queenfish	0.05
Soupfin shark	14.56	California spiny lobster	0.05
Pacific hake	14.41	Yellowfin tuna	0.05
Longspine thornyhead	13.81	Stripetail rockfish	0.05
Rougheye/blackspotted rockfish	13.45	California butterfly ray	0.04
Blue shark	12.19	Lumptail searobin	0.04
Longspine combfish	11.48	Blacksmith	0.04
Starry skate	11.23	Bonito (shortfin mako) shark	0.04
Barred sand bass	10.74	Unidentified pyrosome	0.04
Yellow rock crab	10.73	Gray smoothhound shark	0.04
Fantail sole	10.57	Calico rockfish	0.04
Unidentified shark	10.14	Smooth stargazer	0.03

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Appendix II. Continued.

Other species	Total discards & landings (mt)	Other species	Total discards & landings (mt)
Unidentified sea cucumber	10.1	Rosy rockfish	0.03
Yelloweye rockfish	8.11	Unidentified halibut	0.03
Ridgeback prawn	7.74	Sea pen	0.03
Irregular echinoid	7.12	Xantus swimming crab	0.03
Unidentified sea anemone	7.05	Unidentified sponge	0.03
Swell shark	6.9	China rockfish	0.03
Unidentified crab	6.17	Unidentified greenling	0.03
Armed box crab	5.19	California moray	0.02
Albacore tuna	5.04	Unidentified king crab	0.02
Unidentified Slope rockfish	4.85	Cowcod rockfish	0.02
California scorpionfish	4.63	California barracuda	0.02
Redbanded rockfish	4.6	Unidentified anglerfish	0.02
Pacific sleeper shark	4.02	Masking crab	0.02
Sevengill shark	3.99	Brown Irish lord sculpin	0.02
Plainfin midshipman	3.84	Opah	0.02
Unidentified sculpin	3.82	Humboldt (jumbo) squid	0.02
American shad	3.76	Kelp greenling (California)	0.02
Copper rockfish	3.57	Buffalo sculpin	0.02
Canary rockfish	3.56	Flathead sole	0.01
California lizardfish	3.48	Longfin smelt	0.01
Unidentified shelf rockfish	3.16	Unidentified hagfish	0.01
Shortspine/longspine Thornyhead	3.15	Spotted sand bass	0.01
Unidentified sea snail	3.04	Rubberlip surfperch	0.01
Bocaccio rockfish	2.79	Bull sculpin	0.01
Unidentified fish	2.72	Unidentified roundfish	0.01
Common thresher shark	2.61	Shiner surfperch	0.01
White sturgeon	2.6	Olive rockfish	0.01
Unidentified shrimp	2.57	Flag rockfish	0.01
Pacific staghorn sculpin	2.49	Unidentified ectoprocta	0.01
Unidentified octopus	2.45	Unidentified isopod	0.01
Pacific rock crab	2.44	Unidentified flying fish	0.01
Widow rockfish	2.38	Round herring	0.01
Yellowtail rockfish	2.21	Tanneri tanner crab	0.01
Brown rockfish	2.12	Unidentified sea pen/pansy	0.01
Wolf-eel	2.11	Sarcastic fringehead	0.01
Unidentified sand dollar	1.9	Unidentified scallop	0.01
Darkblotched rockfish	1.89	Unidentified kelp crab	0.01
Sixgill shark	1.79	Pile surfperch	0.01
Blackgill rockfish	1.75	Tiger rockfish	0.01
Unidentified combfish	1.73	Spotted Cusk-eel	0.01
Pacific cod	1.71	C-O sole	0.01
Shortraker/rougheye/Blackspotted rockfish	1.7	Diamond stingray	0.01
Diamond turbot	1.7	Bullet mackerel	0.01
Deepsea sole	1.59	Shortspine combfish	0.01
Unidentified midshipman	1.49	Starry rockfish	0.01
Giant sea bass	1.46	Sea whip/fan	0.01
Unidentified spiny lobster	1.45	Pacific bonito	0.00
Unidentified smoothhound shark	1.43	Surf smelt	0.00
Aurora rockfish	1.36	Unidentified worm	0.00
Pink surfperch	1.35	Pacific sandlance	0.00
Pacific butterfish	1.32	Squarespot rockfish	0.00

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Appendix II. Continued.

Other species	Total discards & landings (mt)	Other species	Total discards & landings (mt)
Unidentified ray	1.17	Unidentified brittle/basket star	0.00
Specklefin midshipman	1.13	Unidentified cod	0.00
Sandpaper skate	1.11	Halfbanded rockfish	0.00
Silvergray rockfish	1.1	Silver surfperch	0.00
Unidentified cancer crab	0.94	White surfperch	0.00
Unidentified rockfish	0.92	Pacific grenadier	0.00
Unidentified decorator/spider crab	0.89	Spotted batfish	0.00
Mixed species	0.88	Unidentified gorgonian coral	0.00
Northern anchovy	0.85	Whitebait smelt	0.00
Shortraker rockfish	0.84	Black croaker	0.00
Quillback rockfish	0.82	Unidentified cusk-eel	0.00
Vermilion rockfish	0.81	Unidentified coral	0.00
Greenstriped rockfish	0.79	Pacific hagfish	0.00
Pacific tom cod	0.77	Bobtail squid	0.00
Cabezon	0.76	Spiny king crab	0.00
Brown box crab	0.7	Unidentified mussel	0.00
Mola mola (sunfish)	0.7	Night smelt	0.00
Unidentified non-humboldt squid	0.69	Horny gorgonian	0.00
Brown cat shark	0.68	Unidentified non-eulachon smelt	0.00
Unidentified squid	0.66	Unidentified ronquil	0.00
Bigmouth sole	0.63	Showy snailfish	0.00
Longfin sanddab	0.62	Gopher rockfish	0.00
Unidentified nudibranch	0.59	Bronzespotted rockfish	0.00
Greenspotted rockfish	0.57	Unidentified squat lobster	0.00
Unidentified anchovy	0.53	Banded guitarfish	0.00
California sheephead	0.51	Blue/deacon rockfish	0.00
Unidentified mollusk	0.5	Mexican rockfish	0.00
Unidentified salp	0.49	Sea whip	0.00
Sunstar starfish	0.46	Pacific sandfish	0.00
Black rockfish	0.44	Red Irish lord sculpin	0.00
Unidentified thresher shark	0.44	Jacksmelt	0.00
Unidentified hermit crab	0.42	Pink rockfish	0.00
Round stingray	0.42	Sharpchin rockfish	0.00
Unidentified bivalve	0.4	Dusky sculpin	0.00
Rosethorn rockfish	0.38	Speckled rockfish	0.00
Unidentified surfperch	0.33	Redstripe rockfish	0.00
Horn shark	0.32	Bay pipefish	0.00
Unidentified wrymouth	0.31	Kelp rockfish	0.00
Rock crab	0.31	Splitnose searobin	0.00
Spotfin surfperch	0.29	Pinkrose rockfish	0.00
Unidentified nearshore rockfish	0.29	Unidentified lumpsucker	0.00
Market squid	0.28	Snubnose pipefish	0.00
California king crab	0.27	Unidentified amiphpod	0.00
Pacific sardine	0.27		

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